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The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT

(THIRTY-FIFTH YEAR)

1947

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1947 to 31st December, 1947

COMMONWEALTH MYCOLOGICAL INSTITUTE
17 DEC 1948

Price 10/- post free Great Britain only

Published October, 1948

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THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

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The correct abbreviation of this issue of this Report is :—
Rep. E. Malling Res. Sta. for 1947 (1948).

PRINTED IN GREAT BRITAIN BY HEADLEY BROTHERS,
109 KINGSWAY, LONDON, W.C.2; AND ASHFORD, KENT

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All visitors wishing to see the work of the Station should go to the Enquiry Office at the Research Laboratories. *It is most important that an appointment be made beforehand.*

Visitors coming by road should take the turning to East Malling, opposite "The Bull", Larkfield, on the main London-Maidstone road. The entrance gate to the Research Station is on the left, opposite the "King and Queen" in East Malling.

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FOREWORD

A new feature in the Report this year is provided by the first of the Amos Memorial Lectures, which are intended to be given annually in future. The genesis and purpose of these lectures were explained in the Supplementary Annual Report issued to our Members earlier in the year.

In other respects this Report for 1947 follows lines similar to those of previous years. In Section I the Farm Supervisor reports a good year in spite of weather that broke meteorological records wholesale. Sections II and III afford evidence of the gradual consolidation of the post-war research programme and also show that, although many of the long-term researches produce their main results slowly, there have been solid additions to knowledge in several directions. The bulletins for fruit-growers in Section IV are written in language less technical than that inevitable in some of the research reports of Section III. We hope that something of interest to our Fellows and Members will be found in all Sections.

Circulated with this Report, although separate from it, is a revised edition of our leaflet on general development and activities. Any historical review of this Station now has to look back over thirty-five eventful years and the occasional backward glance is useful both for the checking of present bearings and for the encouragement that can be derived from the lessons of the past. Leaflet T6 explains very briefly the " why " and " how " of the Station's Programme.

E.E.C.
H.B.S.M.

Section I

THE EXPERIMENTAL FARM

By F. H. VILLIERS, with contributions from F. H. BEARD and T. V. DIXON.

In its late spring, entire absence of damaging frosts during the blossoming period and fine summer and autumn, 1947 perhaps approached the ideal as a fruitgrowers' year. Certainly at East Malling it yielded the heaviest apple crop to date, despite a great reduction in the number of trees in recent years, and was a notable year for Cox's Orange Pippin, whilst other top fruits carried heavy yields. A glance at the Weather Report (see page 85), however, confirms popular opinion that it was a most abnormal year in many respects, and on account of its less favourable features the task of bringing the heavy crops safely to harvest was by no means easy.

The prolonged cold spell early in the year delayed the lifting of nursery materials and made pruning and other operations difficult and unpleasant. Actually, although the air temperature fell to zero on at least two occasions, low temperature injury to mature trees was not severe. A few established Cox's Orange Pippin trees on M.IX rootstock suffered from splits in the trunk bark and some 130 such splits were tacked up, but all healed rapidly in the spring and the trees so treated bore good crops. The young pear trees in the Bradbourne garden, however, suffered considerably. Altogether, 261 trees were killed back to within an inch or two of the union, Laxton's Superb (99 trees damaged) and Beurré Superfin (65 trees) being the worst sufferers. Much of the loganberry and some raspberry cane was also killed.

The blossoming and ripening of most types of fruit occurred a little later than usual. Cherries were in full bloom on 13th April, and apples the first week in May. Cherry picking started on 10th June and apple picking on 30th July. Thanks to the long fine spell in the autumn, all fruit picking was finished by 13th October.

Experimental Orchards.—Top Fruits.

Apples.—The total crop of 23,503 bushels (40 lb. to a bushel) from 49 acres of all varieties in cropping, exceeded by 653 bushels the previous record set up in 1945. Though all varieties cropped well, 1947 was chiefly notable here for the excellent crop of Cox's, the total yield of 3,202 bushels being just over one-third greater than the 1945 figure.

Bramley's Seedling also cropped well, in particular the trees in the original rootstock trial in Great East field, some of which averaged 14½ bushels per tree. The crop of Worcester Pearmain—3,912 bushels—was also very satisfactory and once more demonstrates the remarkable regularity of cropping for which this variety is well known. Yields of Cox's and Bramley's were good in 1945 and 1947 with an off year of negligible crops in 1946. Worcester Pearmain, on the other hand, yielded heavily in 1946, as well as in 1945 and 1947. Lane's Prince Albert has also cropped regularly at this Station ; the trees in the rootstock trial in Great East field, now 27 years old, having averaged 431 bushels per acre over the last 7 years. These trees show no apparent signs of senility and yielded 4½ bushels per tree in 1947.

Nearly all other apple varieties yielded heavily ; some of them, such as Miller's Seedling and Allington Pippin, needed drastic fruit thinning to maintain fruit size.

One of our three cold stores has now been handed over to the Pomology Section for intensive work on frost damage, so little fruit could be stored here. Of the two remaining stores, one was filled with dessert apples, Cox's, Allington and Laxton's, which were cold stored, and the other with Lane's Prince Albert, which were gas stored. 600 bushels of Barnack Beauty were stored in our oast and 2,400 bushels of Bramley's Seedling were cold stored in a meat store in London.

Pears.—After an "off" year in 1946, the Station's pear plantations looked very promising in the early part of 1947, all varieties produced ample blossom which set very well, and there was no excessive drop of young fruitlets. As the season advanced, however, it became apparent that the continued dry sunny weather, whilst ideal for other crops, was having an adverse effect on our closely spaced pear plantations and only the earlier varieties matured their fruits satisfactorily.

Altogether 2,968 bushels (48 lb. to a bushel) were marketed from 7 acres now in cropping. Beurré Hardy 3¼ bushels per tree, Pitmaston Duchess 3 bushels, Beurré d'Amanlis 2¾ bushels per tree and Dr. Jules Guyot 2 bushels per tree—all yielded well. By the time Conference was ready to pick, the

full effect of the prolonged drought was being felt and though a total crop of 532 bushels was picked, some of this was of poor quality.

Plums.—Though there did not appear to be a great deal of plum blossom in the spring of 1947, what there was set well and all varieties bore satisfactory crops, the total marketed was 3,814 halves (28 lb. to a half sieve). The crop of Victorias was almost double the 1946 crop and averaged 4 halves per tree ; the quality of the fruit was good. Czars and Myrobalans, chiefly in windbreaks, contributed 1,509 halves to the total, Ontario 158 halves, Warwickshire Drooper 129 halves and our Gage collection 257 halves. Both Ontario and Warwickshire Drooper have cropped consistently and well in the rootstock trial on Deadman Field ; these trees were planted in 1939 and in 1947 averaged 70 lb. and 84 lb. per tree respectively.

Cherries.—Neither the winter frosts nor the summer drought seems to have affected the sweet cherries in 1947 for the total crop, 1,847 halves (24 lb. to a half sieve), exceeded by 71 halves the previous record set up in 1946. The bulk of the fruit came from the rootstock trial in Church Fields, all three of the varieties cropping well for their age—19 years from planting. Excluding replants, Early Rivers averaged 7½, Turkey Heart 4 and Bigarreau de Schrecken 4 halves per tree. The crop of acid cherries was again disappointing, amounting to only 273 halves from 325 trees. Efforts to promote the growth of young wood by dehorning and branch thinning have not, so far, been very successful and it has now been decided to grub most of the Carnations and Kentish Reds as they are very overcrowded and are interfering with the growth of the young trees of the sweet cherry variety collection with which they are interplanted.

Small Fruits.

The 4 acres of blackcurrants on Merryweather Field in variety and manurial trials, did not crop as well as might have been expected. They made good growth in the wet season of 1946 but " ran off " to a certain extent, and the 1947 crop only averaged 1 ton per acre. The rather exposed position of this field and lack of organic manure on some portions of it may account in some measure for the disappointing crop. As has already been mentioned, the canes of both raspberries and loganberries suffered badly from winter injury and this, of course, considerably reduced the crop. Loganberries yielded only 8 cwt. from 1 acre and raspberries 1 ton 16 cwt. from 2 acres. The drought had not begun to make itself felt in time to affect the strawberry crop, and all trials cropped well, in particular some of the close planted cultural trials.

Fresh Plantings, Grubbings, etc.

During the early part of December, 1946, a further 6 acres (including headlands) of dessert apple varieties were planted on Church Fields. The principal varieties are : Cox's Orange Pippin, Egremont Russet, Orleans Reinette, Ribston Pippin and Sunset in three trials of new rootstocks ; and Tydeman's Harvest, Tydeman's Early Worcester, Worcester Pearmain, Tydeman's Late Cox and Laxton's Superb in a variety trial. A replica of this variety trial in cordon form was planted in the same month and also a further 1 acre of Cox and Worcester for cover cropping and cultural trials was planted adjoining Larkfield Plantation. This makes a total of just over 28 acres (including headlands) of new apple plantations established since the war, and it has become necessary to reduce the number of trees in some of the older plantations so that labour shall be available to look after the younger plantings.

Further thinning of the original rootstock trials, now 29 years old, on Great East Field, has had to be undertaken. All these trials, which included Lane's, Worcester and Bramley's, were originally at 15 ft. square—a distance at first thought generous for trees on Paradise stocks. All the Bramley's have now been thinned twice and are at 30 ft. square, while even the supposedly weak growing Lane's have had alternate trees removed except on the more dwarfing rootstocks.

Other plots that have had to be thinned include the 27-year-old double-working trial which contained various varieties, originally at 15 ft. square, on Great East Field, and Cox's on Crab and Paradise stocks (mostly No. II) on Kiln Field. A start has been made to remove the Morello and Kentish cherries in a rootstock trial, which were badly overcrowding the standard sweet cherries between which they were planted. In addition, a small dwarf pyramid apple trial and the old ecological plot were grubbed in 1947 ; the remainder of the stoolbeds in Newgates Field and 3½ acres of raspberry propagation beds at Bradbourne were also removed.

Arable Crops.

Cover crops in the 1945 plantations, instead of arable crops between the young trees, and the planting of a further 7 acres of one-year-old apples, reduced the area available for arable crops in 1947 to 144 acres, compared with 164 acres in the previous year. The bad weather in the autumn and winter made it impossible to clear the remainder of Newgates stoolbeds in time for cropping, and as most of

the grubbing done consisted of thinning, no fresh ground was added to the arable acreage. The land was cropped as follows :

Potatoes.—Twenty-four acres of Majestics were grown, and in spite of the dry season and the fact that they were not planted until May, the yield was well over 8 tons per acre. Some 91 tons were sold to the Ditton Laboratory and the remainder, apart from the M.O.F. end of season reserve, disposed of through ordinary trade channels before the end of the year.

Peas.—Eleven acres of early, and 9 acres of main crop peas were grown for canning. The early varieties, Alaska and Surprise, averaged just over 1 ton of shelled peas per acre and the main crop, Lincoln, 22 cwt. These yields, whilst much less than last year's exceptional ones, were well up to the average of other peas grown locally in 1947, according to information obtained from the cannery.

Cereals.—Twenty-five acres of Plumage Archer barley did well, yielding almost 5 qr. per acre, but the 24 acres of wheat suffered considerably during the severe winter and averaged only $3\frac{1}{2}$ qr. per acre.

The 25 acres of barley were undersown with one year seeds in the spring and a good plant resulted. Yields of hay from the 1946 sowings were not heavy as most of this came on the lighter Larkfield ground, and instead of increasing as the season advanced the crop was reduced by drought. No second cut was taken, all the ley ground and part of the pea ground was bastard fallowed instead. Many ploughings and cultivatings resulted in the destruction of much couch and other rubbish.

In addition, some $7\frac{1}{2}$ acres of mangolds, kale and cabbage were grown in readiness for the 1947 bullocks. During the season 1946-47, two yards of Devon Steers were kept, 34 beasts in all. These throve through the winter and sold well.

Routine Spraying Programme.

The prolonged spell of wet and frosty weather, lasting from early December until well into March, made winter spraying exceedingly difficult in the 1946-47 season, and emphasized once more the necessity of having ample spraying machinery so that the fullest use can be made of any short spells of suitable weather. The additional mobile outfit purchased by the Station in 1946 proved invaluable and with its aid it was possible to finish winter spraying by the 27th March.

All apples were winter washed again this year either with 5 per cent. Tar Oil followed by 4 per cent. Petroleum or with 8 per cent. D.N.C. On Kiln Field and on one cover crop trial on Egham Field, the concentration of D.N.C. was reduced to 4 per cent. and 0·1 per cent. DDT was added to the green cluster Scab spray. This lower strength of D.N.C. is adequate to control Aphid and Apple Sucker and to reduce the number of Red Spider eggs, while the risk of damage to wood and fruit buds, which sometimes follows the use of 8 per cent. D.N.C., is greatly reduced. The DDT added to the green cluster Scab spray effectively controlled Capsid and Caterpillar, and applied thus, early in the season, does little harm to the predators of Red Spider.

It was decided to spray all pear plots with 5 per cent. Tar Oil in 1947, as these plots had received no winter wash in the two previous seasons, and it was thought desirable to prevent the possibility of any build-up of the aphid population, a precaution which events proved to have been wise, as aphid attacks were generally severe elsewhere during the summer. All cherries received the two Bordeaux mixture sprays recommended in the Spray Calendar for the control of Bacterial Canker, and to the spring application 0·1 per cent. DDT was added for the control of Winter Moth caterpillars. This use of DDT obviates greasebanding in the autumn and spring, for which most cherry growers will be grateful. No sweet cherries were winter washed as this has been done regularly for some years past, and little black fly has been noted.

The fine dry summer provided plenty of days suitable for spraying but the very hot spell between 16th April and 14th May caused the blossoms to open very quickly, and some difficulty was experienced in getting the pink bud Scab spray on soon enough. All apples received two pre-blossom applications of lime-sulphur, the first at $2\frac{1}{2}$ per cent. and the second at 2 per cent. To the first was added 2 lb./100 gallons of lead arsenate for the control of Caterpillar except on Kiln Field, where 0·1 per cent. DDT was used instead to control both Capsid and Caterpillar, which it seemed to do very satisfactorily. The post-blossom Scab spray programme was varied to suit each particular variety ; sulphur-shy sorts were sprayed twice with dispersible sulphur, and others with lime-sulphur at reduced strengths. Scab control was good generally except on Bramley's where, in spite of careful timing and application, results were indifferent. All Bramley plantations have now been vigorously pruned and it is hoped that this, combined with the use of a more driving spray, will achieve better results next year.

Nicotine (8 oz./100 gallons) was added to the petal-fall spray for the control of Sawfly, but a cold snap just about this time considerably reduced the efficacy of this measure, and Sawfly larvae caused some damage. Codling Moth was also difficult to control, owing to the prolonged hatching period ; it looks as though two sprays will be necessary every year to keep this pest under.

All pears received two Bordeaux mixture sprays before blossoming, to the first of which 2 lb. of lead arsenate was added. After blossoming, two dispersible sulphur sprays were applied, but in spite of these four sprays Scab control was indifferent, especially on Williams's.

Black currants were winter washed with D.N.C. at 8 per cent., and just before the blossoms opened were sprayed with lime-sulphur at 2 per cent. Big Bud was controlled but there was some damage from Capsid attacks on the young growing shoots, and Black currant Midge was also much in evidence. This last named pest is receiving the close attention of our Entomology Section. Raspberries and loganberries were sprayed in accordance with the Spray Calendar recommendations and clean crops resulted.

F.H.V.

Experimental Nurseries.

After the prolonged winter there was a race against time in the spring to complete the harvesting of our rootstocks and to get all the layers in the stoolbeds pegged down and covered before growth had progressed too far. Fortunately, the weather once changed remained good, and by concentrating all available labour on the job we soon managed to catch up.

The crop of rootstocks was 582,380 of all grades. This total, though less than last year, may be considered satisfactory as the remainder of our old stoolbeds were grubbed the previous autumn, and only the ten acres of new stoolbeds in Ditton Fields now remain. Of this total crop of 582,380 rootstocks harvested 222,780 were first grade, 181,000 were second grade and the remainder, 178,600, were non-rooted. The majority of these last were bedded back for a further year in the nursery. All apple and cherry rootstocks were dipped in 5 per cent. tar oil before being distributed, as the previous summer had been a particularly bad one for aphid attacks, and in spite of frequent sprayings and dustings it was felt advisable to take this additional precaution.

Red Spider was also troublesome in the nursery during the summer, but spraying with Summer Petroleum and Derris gave good control.

Nearly 5,000 maiden trees were lifted, the majority of which were required for experimental purposes ; the total included 3,463 apple trees, 762 pear trees, 404 plum trees and 188 cherry trees.

The cane nurseries of Malling Promise and Malling Landmark raspberries yielded 103,500 saleable canes, but on account of the occurrence of "Dwarf" disease amongst the Malling Landmark, canes were sent out on condition that they should be used for fruiting purposes only. Smaller lots of other raspberry varieties and seedlings were also raised.

Certified bushes of black currants raised totalled 9,903 of first and second grades. Of strawberry runners, now raised only for new special stock nurseries, there were nearly 50,000 of all grades. Although the season was dry and the plants consequently rather small, they were well rooted and the majority were despatched in the autumn.

T.V.D.

Hops

The acreage under hops remains unchanged at 9½ acres. Only three varieties in the Seedling garden were grubbed to make room for new selections.

With hops also, the weather greatly delayed cultural operations so that " dressing " was not completed until the middle of April. The rainfall during May and June was slightly above normal, whilst the first three weeks of July were very wet. As a result Downy Mildew spikes were plentiful, lateral spikes at the end of July being numerous on many varieties. A change to drought conditions in August made Downy Mildew no longer a trouble but favoured a rapid increase in the Red Spider population at a period when the standard control of 1 per cent. lime-sulphur could not be applied. The hops showed no signs of distress until the end of August, but from then onwards the effect of drought and Red Spider became increasingly evident. Rain which came on 17th September was too late to be of any great benefit. Bradbourne Golding hop garden, no doubt owing to its situation on low ground near a small stream, suffered little from either drought or Red Spider. Our total growth was just over 6½ tons and must be considered satisfactory as it has only been exceeded on three occasions in the past.

Demand for sets of the chief New (Wye) Varieties still far exceeds the available supply. Some 2,300 sets were raised and distributed amongst eight growers. In addition about 6,500 sets of Fuggle and New Varieties were raised for the use of the Pathology Section in their Verticillium Wilt investigations.

The table below gives the valuations placed on the principal growths. Once again we are indebted to a well-known firm of brewers for analysing a number of varieties and buying them on the basis of

their P.V. (10_a) content. It will be seen that in 1947 the differences between the ordinary and P.V. valuations were very great. This is in part due to the fact that the ordinary valuations are in the main a reflection of the varieties' resistance to drought and Red Spider. The garden of clonal Goldings at Bradbourne was little affected by drought or Red Spider, so that the ordinary valuations of these varieties may be considered to represent true varietal differences in market value.

F.H.B.

HOP VALUATIONS, 1947 GROWTHS (PER CWT.).

Variety.		Ordinary valuation. £	s.	Valuation on P.V. (10_a) basis. £	s.
Brewer's Favourite (OP21)		23	0		
Brewer's Gold (C9a)		21	15	41	5
Brewer's Stand-by (HH44)		25	0	29	13
Bullion Hop (Q43)		22	0	40	13
College Cluster (N15 bis)		22	0	20	1
Concord Hop (OH44)		23	5		
Early Promise (X35)		22	10	22	10
Fillpocket (Z62)		23	5		
Malling Midseason (BB28)		23	5	32	2
Northern Brewer (WFA12)				39	18
Sunshine Hop (V94)				27	16
Quality Hop (OO63)		25	0		
Wye Field Golding (WFC81)				38	14
Mixed Growths (New Seedlings)		23	15		
Fuggle		23	15		
Bramling	Clonal Goldings	27	5		
Early Bird		27	0		
Canterbury Golding		27	0		
Eastwell Golding		26	5		
Mathon		27	5		
Petham Golding		25	15		
Rodmersham Golding		27	0		

Section II

GENERAL REVIEW OF RESEARCH WORK
WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By W. S. ROGERS.

A.—Tree Fruits.—Rootstocks.

The long-term rootstock trials of apples, pears, plums and cherries have been maintained, and, once more, good crops were harvested. Apple trees on M. IX rootstock still show no sign of senescence, at the age of 30 years.

The rootstock trial of Early Rivers, Bigarreau de Schrecken and Turkey Heart cherries, on selected vegetatively propagated Mazzards, now nineteen years old, bore its heaviest crop so far. Early Rivers bore upwards of 200 lb. per tree.

The trees, all bush, in the trials of Frogmore on acid cherry rootstocks, now four years planted, carried a few fruits ; those on the acid cherry stocks bore considerably more than those on the two selected Mazzards used as controls. The trunks of the trees on Mazzard are as thick below the union as they are above but those on acid rootstocks are very much smaller below than above the union.

A new consignment of a clonal " Kentish " cherry rootstock and maiden trees of sweet varieties worked upon this, were received from Victoria, Australia, during May. The unworked rootstocks have made excellent growth and will be tested alongside our original clone. The maidens have failed to grow normally, exhibiting the symptoms of delayed dormancy generally associated with lack of winter chilling.

The Peregrine and Sea Eagle peach trees in the rootstock trial on the walls at Bradbourne have grown well and made a framework from which it should be possible to form well-shaped fan trees.

Breeding work among the apple and pear rootstocks has not yet been resumed, but intensive trials are being continued on promising new rootstocks already raised. A close study of varieties of quince imported from the Continent and said to be especially suitable as rootstocks for pears, is being made. An attempt to evolve new pear rootstocks by hybridization between the pear and quince has not so far proved successful.

Work on the provision of a wider range of plum rootstocks has been intensified. A paper has been published on the application of biological observations on wild and naturalized species and varieties of fruit trees to the study of Prunus rootstocks (E257).

A biological expedition to study Prunus rootstocks in France was undertaken in June, 1947 in collaboration with the A.R.C. Unit of Biochemistry at Cambridge. The regions visited were mainly in the river valleys of the Loire and Lot and in the Western Pyrenees. Seed and budwood of various forms of Prunus were collected for trial at the Research Station.

From the different kinds of Pershore seed collected in Worcestershire in 1946 seedlings of sixteen forms have been raised in an attempt to select new and improved Pershore rootstocks. These seedlings have been graded according to the structure of the tap root and planted in a nursery trial.

New Rootstock Trials.

Two preliminary small scale field trials of the " IX Crosses " (new apple rootstocks raised by crossing M. IX with other stocks of the Malling series) and rootstocks tested for immunity to Woolly Aphid have been maintained. Trees in both these trials cropped heavily in 1947 and their performance will supplement observations made on the younger full-scale field trials.

These new rootstocks have been planted in three trials on each of two soils according to their expected vigour following an anatomical examination of their roots ; thus pruning and other cultural treatments can be suited to the vigour of the rootstock as well as to the needs of the scion variety.

Histological Investigations.

A report on the relationship between the histological structure of the stems of fruit plants and the production of adventitious roots in cuttings and layers is in preparation. Further nursery trials of cuttings of Prunus rootstocks and varieties have been planted in connection with this work.

The per cent. root bark has been measured in some apples and plums for a study of its relationship to the growth and fruiting of the stem in (1) lateral roots from mature trees of two apple varieties on a range of Malling clonal rootstocks and (2) tap roots of unworked seedlings of Prunus species and varieties.

Material has also been prepared for a study of the root and stem structure of (1) Lane's Prince Albert and Bramley's Seedling apples on some of the Malling clonal rootstocks and (2) unworked plants of Brompton, Brussels, Common Mussel, Damas C, Marianna, Pershore and St. Julien A plum rootstocks and Malling I, II, IV, VII, IX and XVI apple rootstocks.

In a series of new clonal apple rootstocks, the percentage root bark and also the relative amounts of rays and fibres in the wood of the root were found to be correlated with the vegetative vigour and fruitfulness of a scion variety budded on them. These studies were published (E 269).

The study of the structure of graft unions in incompatible and compatible combinations has been continued. Sections have been prepared for further investigation of the unions between Williams' Bon Chrétien and some new quince rootstocks.

The monthly survey of the fine fibrous roots of M. II apple rootstock begun in November, 1946 was completed in November, 1947. An estimate of the amount of mycorrhiza present and of the variation in the fat and starch content of the fine roots was made.

New Plantations.

An intensive soil survey of the two new apple plantations, Churchfields and Larkfield, established during 1945 and 1946 has been described (E262).

Tree growth on the Churchfields plantation was good in 1947, but on the sandy Larkfield plantation, especially the plantings on the Bearsted Series, growth was severely checked by summer drought. Trees were mulched and stimulating fertilizers applied as remedial measures; these were largely successful following the heavy rainfall during the latter part of July. Trees on this plantation, a typical piece of marginal land, will need careful management.

Propagation.

Intensive studies of the factors concerned in the regeneration of cuttings have been continued, in close collaboration with the Physiology Section (see III. A). A paper on the results of large scale spacing trials with hardwood cuttings over a three year period was published (E 271).

The preparation and maintenance of mother plants to give adequate supplies of cutting material of known history has proved of major importance in the work. The hedges maintained on the contrasting soils at Woking and East Malling have provided cuttings for further trial. Mother plants have also received special treatments, including manuring, root restriction (pot-binding) and shading, designed to affect the regeneration of cuttings taken from them.

Root cuttings of the apple rootstock Malling Crab C taken from trees worked with selected varieties have been planted to observe the effect of scion variety on the performance of the cuttings. Sufficient mother trees have been left in position to provide roots for a further trial next year. The extensive stool- and layer-beds of experimental rootstocks and the collections of rootstocks found in commerce have been maintained and numerous sets of these have been sent to research and education centres at home and overseas, often in exchange for specimens not previously in our possession.

Double-working.

Williams' Bon Chrétien pears, double-worked on quince, now six years from planting, are about to come into cropping; a few of the trees have each borne some nine pounds of fruit. As cropping increases more distinct differences may appear between trees of different combination than are to be seen at present. In many of the union-bridged single-worked trees the bridges have now taken over the duties of the main stem. In one or two the original union between the pear and the quince has snapped and the bridge is now providing the tree's sole support.

The failure of the graft-union between President plum and Myrobalan B rootstock, following topworking with Victoria, is now beginning to be seen in the second batch of trees of this combination. The trees of Victoria over President stems have cropped rather more heavily and ripened two weeks earlier than adjacent trees of Victoria over Victoria; also the foliage was distinctly more yellow by July. Half the trees were allowed to retain " feathers ", or side shoots on the trunk, but so far there is no consistent difference between feathered and clean-trunk trees. A larger batch of trees is now to be contructed for more detailed testing.

In cherry stems grafted in the nursery with a ring of rind of other species, in an attempt to induce restricted growth suitable for bush culture, the ring has often become bridged by rind growth from the

original stem, thus vitiating any permanent effect of the ring. It therefore seems unlikely that this technique, as it stands, will prove helpful in the construction of bush cherries.

Cover Cropping.

The trial of five different cover crops as short-term leys is in its second cycle. The results of the trial involving three different grass and clover swards, combined with differential manurial treatments, are being reviewed for publication. The beneficial effects of a system of orchard management involving the use of a frequently cut sward with liberal applications of nitrogen are clearly shown, but the investigation is being continued to provide further information. Valuable experience in the management of a number of annual and biennial cover crops is being obtained in the preliminary trial in a plantation of Cox and Worcester on IX, in which permanent grass, farmyard manure and straw with " artificials " are included for comparison. Observations are still being made on several apple and cherry orchards in which grass and cultivation are being broadly compared as systems of management.

The small plots in the " cover crop museum " continue to yield valuable information about many herbage species, some of which may be tried later as cover crops in orchards. A similar " museum " has been established during the year on the sandy soil at Larkfield. Trees have also been planted at Larkfield for a trial of effects of various forms of cover cropping and manuring on both soil and trees. It is hoped to start applying treatments during 1948.

Inorganic Fertilizers.

Although scorching of the leaves was generally not very severe in 1947, contrasts were seen on the Bramley's Seedlings showing the residual effects of potash in the presence and absence of continued nitrogen applications. In the trial of Cox's Orange Pippin and Beauty of Bath on M. IX, I, V and XII there are still large differences between plots receiving low and high potash, and nitrogen effects can also be seen. This Plot is now overcrowded and the trees will be thinned during the winter 1947-8.

Soil Moisture.

Soil moisture tensiometers have continued to give valuable information in connection with cover cropping, biennial bearing and irrigation experiments (see Small Fruits).

Pruning.

The preliminary trial of Renewal versus Established-spur pruning methods, applied to vigorous 34-year-old trees of Cox's Orange Pippin has been continued and a progress report published (E261).

Young trees of Cox's Orange Pippin, Worcester Pearmain and Laxton's Superb on M. II and M. IV planted on two soil series, comprising part of the new plantations, have been set aside for the further study of biennial bearing ; and pruning methods are being compared in relation to this problem. The trees are being grown as open centre, delayed open centre and regulated bushes and Established-spur and Renewal pruning systems were started in 1947 upon both the open centre and delayed open centre trees. Some of these trees, mainly the regulated ones, have already borne fruit at three years old from the bud.

Five methods of forming delayed open centre trees, including two methods of group disbudding practised in the U.S.A., are to be tried. Two varieties on M. VII have been planted for this trial—Cox's Orange Pippin, which breaks its buds and forms branches readily, and Worcester Pearmain which is a difficult variety to form into a delayed open centre tree.

Trees of the English Morello cherry, forming the original rootstock trial for this variety, were dehorned in 1946 and four pruning treatments are being tested with the object of maintaining a regular supply of young bearing wood. The treatments include a method of leader tipping and dehorning carried out during late April and the cuts carefully painted with specially thick white lead paint to prevent infections with the silver leaf disease, which was present in some trees before dehorning. This precaution appears to have been successful.

Records have been continued on the apple and pear summer pruning trials in the Bradbourne Gardens.

Fruit Thinning.

In the long term apple thinning trial begun in 1945 on sixteen year old trees of Duchess' Favourite on M. IX, trees are thinned annually by the leaf count method, retaining one fruit per ten, twenty or thirty leaves. The unthinned control trees which cropped heavily in 1945 and yielded very few fruits in 1946, cropped heavily again in 1947, though there were fewer fruits than in 1945. All the thinned

trees again carried a good crop and seem to indicate that even light thinning is better than no thinning at all, but the later the thinning is carried out the more drastic it must be to ensure a satisfactory crop the following year.

Biennial Bearing (see also under Pruning).

Good progress has been made with the work on biennial bearing. Intensive studies of spur, shoot and trunk growth of trees in " on " and " off " year condition, and of regular and biennial varieties were continued. Striking contrasts in leaf area and in periods of leaf development were observed.

The results of reducing the fruiting of branches of trees in " on " year condition by " bud rubbing " and blossom thinning in 1946 were found to be very promising and similar treatments were repeated on whole trees in 1947.

Tests of partial defoliation of trees in " off " year condition with the object of checking the laying down of too many fruit buds, were continued on whole trees. Defoliation by certain sprays was also promising.

Injection of branches of " on " and " off " year trees with solutions containing N, P and K, alone and in combination (in collaboration with the Biochemistry Section) did not affect their biennial performance, suggesting that deficiency of these elements was not a major factor in the trees concerned.

Preparations have been made for continuing and extending the work along the promising lines indicated.

Frost Damage Investigations.

The exceptionally severe winter conditions, especially during January and February, 1947, when minimum screen temperatures reached 0° F., gave an opportunity to study winter frost problems in relation to top and bush fruits. Fortunately, complete killing was rare, though some young pear trees, especially of the varieties Laxton's Superb and Doyenné d'Eté, were killed. Symptoms of frost damage were often sufficiently marked, however, to allow a study of various factors in relation to winter injury.

In apples and pears damage to the young shoots and spurs was shown by blackening or browning of the pith. Marked varietal differences were found. Contrasting damage to shoots of various rootstocks was also seen. The effects of manurial and pruning treatments were also studied.

Bud killing was observed in pears, apricots, peaches and cherries and a very little in plums. Loganberries and raspberries suffered damage and also warm-water-treated strawberries.

A study was made of the callusing and " taking " of apple and pear graft wood where the pith had been discoloured. This damage did not prevent the grafts from callusing and taking normally.

Bark splitting was observed in several mature trees of Cox's Orange Pippin on M. IX at East Malling and on various stocks at Lamberhurst. Most of the cracks were nailed up, but a few were left untreated for observation.

Various other forms of winter injury were observed in other parts of the South-Eastern area.

During the blossom period of 1947, observations on air temperatures were made on the new Churchfields and Larkfield plantations, comparing in each case the conditions over cultivated soil and over an oat and tare cover crop.

The work on spring frost injury is being developed. Studies have included :—

(1) The effect of pollination, including self- and cross-pollination, on susceptibility of flowers to spring frost injury.
(2) The effect of frost on (*a*) germination of unfrozen pollen on frozen styles and (*b*) pollen tube growth following freezing of pollinated styles.
(3) Embryological development in relation to the stage at freezing (*a*) before fertilization, (*b*) after fertilization and (*c*) at proembryo stage.
(4) Measurement with thermocouples of temperature inside freezing flowers as affected by (*a*) age of the flower, (*b*) variety, and (*c*) application of protective substances (foam and methyl cellulose).
(5) Measurement of rate of desiccation as a method of determining frost resistance ; rate of loss of weight of unfrozen and frozen flowers ; rate of loss of weight and rate of transpiration of unfrozen and frozen leaves.
(6) The effect of protective substances upon the amount of damage to flowers during freezing or following it.

It is too early to discuss any results in detail, but it may be worth noting that foam, whose properties as an insulator have proved so valuable in fire fighting, has proved useless as a protector of blossoms against frost, under the conditions of these tests.

Freezing was carried out in one of the Research Station's commercial cold stores, in which it was

very difficult to maintain the required conditions. Plans have now been made and approved for two special research freezing chambers which should greatly facilitate this work.

A paper (E263) has been published on "Green Blotch", an abnormal tissue of apple fruits probably associated with spring frosts.

Varieties and Classification.

The various variety collections, for research purposes, including apples, pears, plums and cherries, have been maintained and have continued to provide valuable material for many studies, including those of winter and spring frost and of biennial bearing.

A new variety collection of cherries, raised for the National Fruit Trials, was planted out at Grove End Farm, Tunstall, in April, 1947. Upward of 200 sorts, all high-worked on the layered Mazzard rootstock F12/1 are included.

A monograph on cherries is in the press.

In the dessert plum variety trial some of the gages and other high quality plums, namely Denniston's Superb Gage, Reine Claude de Bavay, Late Orange, Bryanston's Gage, Cambridge Gage, Craszinski Gage, Laxton's Gage and Ontario bore from 20 lbs. to 50 lb. per tree at ten years from the bud.

Botanical description of the vegetative and reproductive organs of a collection of apricot varieties has been continued. Some of the trees were killed by severe weather conditions during the winter.

The fan-trained acid cherry varieties cropped well, but made little new growth owing to the summer drought.

Plant Breeding.

With the object of producing improved late flowering and frost resistant apple varieties, crosses were made in 1947 between varieties thought likely to transmit these characters.

About a thousand apple seedlings on dwarfing stocks cropped well and some have been selected for further trial as possible new early-ripening dessert apples. Frameworked trees of the named varieties raised at the Station gave heavy crops and have confirmed their early promise. Fruits of Tydeman's Late Cox are being sent for storage tests at the Ditton Laboratory.

Several very promising new varieties have been selected from a trial of about one thousand pear seedlings which fruited heavily. The characteristic "Williams'" flavour and appearance has been transmitted to several seedlings whose fruits mature at widely different seasons.

B.—Small Fruits.—Varieties and Classification.

Raspberries.—For the sixth year in succession, Malling Landmark cropped more heavily than any other variety in the oldest trial. Its crop in 1947, however, was only slightly heavier than that of the second variety, Malling H. The slight relative fall in the crop of Landmark is almost certainly due to the removal of several plants infected with "Dwarf" disease, to which it appears rather more susceptible than any of the other eight varieties in the trial. Malling H appears so far fairly resistant to the disease (see also V. C, 2).

The heavy crop borne by Malling H brings it, on the six year average, up to second place. Nevertheless, Landmark is still on the average 34 per cent. ahead of it and is now 44 per cent. ahead of the third variety, Norfolk Giant. These three are all fairly resistant to Raspberry Cane Midge and Cane Blight. Malling Enterprise, the most susceptible of these nine, and some other varieties, have not yet fully recovered from the setback they sustained in 1945 and 1946 through attacks of Midge and Cane Blight (see V. B, 3 and VI. B).

This year's crop of Landmark and Malling H on the average of six 50-foot rows was the equivalent of slightly over four tons per acre; the best single row reached nearly five tons. Norfolk Giant cropped very poorly, with only 22 cwts. per acre. This was caused by the death of many canes in the winter and spring which was clearly not due to Midge or Cane Blight, and was attributed to winter injury in January and February. In this particular winter, Norfolk Giant was less hardy than any other variety in the trial, but this may not always be so. The crop of two or three other varieties may have been reduced by the same cause.

The small second trial of the recently named "Malling Notable" (N, 32/163), "Malling M" (32/138) and "Malling J" cropped very heavily, both Notable and M having yielded the equivalent of just over 5 tons per acre, with J slightly behind at nearly $4\frac{3}{4}$ tons.

Loganberries and other hybrid berries.—The Rubus variety collection has been seriously affected by "Dwarf" disease and many plants have had to be grubbed. Enough remain, however, to make it worth while maintaining the collection at present.

Red Currants.—The red currant variety trial bore a good crop. A few bushes have died as a result of infection by *Armillaria mellea.*

Black Currants.—In the trial of eight important varieties, Triple X was the heaviest cropper.

Strawberries.—In the stock trials of virus-tolerant varieties, Huxley M. 44 remained the highest cropper, producing over 4 tons per acre. Perle de Prague also yielded over 4 tons per acre this year ; this vigorous early-ripening variety, having good quality fruits, is promising and a Special Stock tested clone of it, Perle de Prague, Malling 45, has now been released. Perle de Prague blossoms rather early, but in 1947 no frost damage to blossoms occurred. The absence of spring frosts was also reflected in a relatively low percentage of misshapen fruits on the varieties Oberschlesien and Tardive de Leopold.

New plantings for cropping trials include Auchincruive Climax, Perle de Prague and Madame Lefebvre.

In the stock trials of virus-sensitive varieties, Royal Sovereign M. 40 is still the heaviest cropper, closely followed by M. 35. In this dry year the yield was only about 2½ tons per acre. Several new clones of Royal Sovereign and Paxton are under test.

Propagation.

Strawberries.—A report (E264) on developments in the Isolated Block system of raising strawberry runners has been published. A further comparison of single and double blocks made in 1947 confirmed certain advantages of the latter.

Only small nuclei of the older Special Stock clones were maintained, in accordance with the agreed policy. The dry summer, and attacks of Verticillium Wilt in some cases, further restricted runner production.

The first large scale runner bed of the new tested clone Perle de Prague, Malling 45, produced about 8,000 plants, which have been distributed, for the first time, to a number of Special Stock nurseries. A clone of Madame Lefebvre, raised in quantity with a view to its introduction to the Special Stock Scheme, was not distributed, however, as it did not reach the desired high standard of cropping, and it is thought that better clones may be found. This risk of loss has to be faced whenever new clones are propagated in quantity before cropping trials are completed ; but it has been taken in several cases, in view of the strong demand for tested clones of all the main varieties at the earliest possible moment.

Small numbers of plants of tested clones of many standard varieties were once more raised in the insect-proof " gauze house ". Better runner production than in former years followed the changing of the soil and the replacement of the old dense gauze with new gauze of 35 S.W.G. copper wire, with 40 meshes to the inch. These nuclei, which have been protected from possible re-infection, are used each year to re-establish our outdoor runner beds. Limited quantities have also been placed on other selected nurseries and some have gone to overseas workers. A second gauze house erected in the autumn will help to house the ever-increasing number of tested stocks and to maintain the supply of material of the highest degree of virus-freedom. As this work increases, the need for a separate centre for the maintenance and propagation of these tested stocks becomes more pressing.

Raspberries.—The large scale cane nurseries of several new seedlings are now in full production. Unfortunately a considerable outbreak of Dwarf occurred in the bed of Malling Landmark and no plants of this variety were distributed for further propagation.

Breeding.

Raspberries.—The youngest batch of seedlings, of which a few hundred bore some fruit in 1947, was much injured by the bad weather of 1946. A few further selections have been propagated, canes having been planted both at East Malling and in Scotland ; but the great majority have not yet given any indication of their value. It is intended to make a thorough survey of them in 1948.

Black Currants.—Although no further crossings between black currant varieties have been made, trials have been continued with promising seedlings raised in previous years. Several have been sent to the National Fruit Trials.

Strawberries.—Well over one thousand strawberry seedlings have been planted out for fruiting. They are from selfings and crossings of many of the principal commercial varieties. Material is being worked up for an extended trial of a few promising selections from a family of selfed Sovereign seedlings.

Root Studies.

Raspberries.—Another fruit was added to the series of studies of root systems of fruit plants, by the excavation of the root systems of mature plants of the raspberry varieties Norfolk Giant, Newburgh and St. Walfried. Descriptions were published (E270).

Cultural Measures.

Loganberries.—Manurial and cover-cropping treatments have been continued on a trial of clonal loganberries. Winter injury to the cane in the early months of 1947 seriously affected the crop. The cane growth, however, was very good in spite of the drought and the plants should bear well in 1948.

Black Currants.—The pruning trial in which bushes planted at 5 ft. apart in the rows, receiving normal winter pruning, are compared with others planted 3 ft. apart in rows, alternate bushes of which are cut down to the ground every other year, has been continued. Another pruning trial has begun, designed to show any effect on crop caused by pruning immediately after fruiting compared with normal winter pruning. Both treatments are subdivided and receive either summer or winter nitrogen.

The manurial trials (*a*) in which straw, farmyard manure and meat and bone meal are applied every two years, and (*b*) involving annual applications of various organic and inorganic manures, are being continued.

Strawberries.—The cultural trials comparing strawberries growing in spaced rows, matted rows and matted beds showed that, even in a dry year such as 1947, the matted rows and matted beds gave yields up to 100 per cent. greater than the spaced rows ; there was no significant decrease in size of berry, or increase in percentage of rotten fruit. Three spacing trials with Royal Sovereign have now been completed, and are being reviewed with a view to establishing the factors involved in optimum spacing of fruiting plants.

The spread of the Strawberry Tarsonemid Mite, favoured by the hot summer, has unfortunately made it necessary to plough in two trials after only two years' observations. New attempts to obtain control of the mite, under field conditions, by fumigation (in collaboration with the Entomology Section) have not, so far, proved successful.

New trials planted in autumn, 1947, include one in which cultural methods and burning treatments will be combined, on the variety Huxley.

Irrigation.

The dry summer conditions provided an opportunity to repeat the irrigation trial of strawberries. Two applications, each equal to 1 in. of rain, were given with favourable results. The series of irrigation trials is now ready for review.

C.—Nuts.

The cold winter of 1946-7 killed back some of the one-year-old shoots, particularly on late leafing walnut varieties, possibly because these varieties did not have time to ripen their wood properly in the wet and sunless summer of 1946.

The cold weather delayed leafing out of early and mid-season varieties, so that they leafed out at the same time, and not very much earlier than the late varieties.

The flowering season was short and pollen shedding overlapped more than usual with the time at which the pistillate flowers were receptive. For this reason, and because of good weather, pollination was good, in spite of the fact that many catkins had been killed by the severe winter. Most trees carried good crops, fairly free from Bacterial Blight. A plot of sixteen trees planted in 1928 bore an average crop of 40 lb. of green nuts per tree.

A paper (E256) has been published on " Growing Walnuts in England ".

D.—Horticultural Meteorology.

The routine meteorological observations were maintained. Special records of air and soil temperature and soil moisture in relation to various experiments were continued. The replacement of the existing faulty pressure tube anemometer by a new one has been sanctioned, since these records are so valuable to the research programme. Cup counter anemometers have been erected at the Research Station and on the Soil Survey plots at Bredgar and Faversham. Readings are taken at regular intervals and should prove valuable in assisting the interpretation of cropping behaviour on these plots.

Assistance has been received during the year from the Meteorological Office, Forecasting Department, who kindly sent frost warnings which have enabled precautions to be taken for safeguarding special plants from frost damage.

In Relation to Tree Fruits.

Water and the Fruit Grower. D. W. P. GREENHAM. Farming, 1947, **1**, 259-60. (E254.)

Factors affecting soil water content are discussed in relation to the needs of plants and practical conclusions are drawn.

Growing Walnuts in England. ELIZABETH M. GLENN. Rep. E. Malling Res. Sta. for 1946 (1947), 160-4. (E256.)

The Application of Biological Observations on Wild and Naturalized plants to the Study of Fruit Tree Rootstocks. A Study of Some Prunus Species. R. HILL and A. BERYL BEAKBANE. J. Pomol., 1947, **23**, 117-33. (E257.)

1. An attempt has been made to define some of the main desirable properties of fruit tree rootstocks.

2. The properties chosen for consideration are grouped as follows :—

(1) indication by direct observations in the field on (i) ease of vegetative propagation, (ii) working, (iii) vigour ; and

(2) indication by experimental trials of compatibility of rootstock and scion.

3. A description of apple rootstocks is given showing how the effect of the unworked rootstocks of extreme types on their own stems agrees in general with their effect on scions worked on them.

4. Observations have been made on wild and naturalized fruit trees which show the existence of a greater range of useful material than is usually available in ordinary horticultural practice.

5. Possible methods of recognition of properties in the field are discussed. This might result in the rapid recognition of good types for experimental trial.

6. Ease of vegetative propagation with field material was tested by growing cuttings.

7. The data on habit of growth in relation to amount of living tissue in roots obtained from the unworked extreme dwarfing types of apple rootstocks have been found to apply to certain species of Prunus.

8. When making use of the present hypothesis in estimating vigour it was found necessary to measure the variation of per cent. bark in relation to thickness of root.

Some Preliminary Investigations on the Growing of Walnuts in England (1925-46). ELIZABETH M. GLENN, R. G. HATTON and A. W. WITT. J. roy. hort. Soc., 1947, **72**, 269-74. (E258.)

The paper deals with the reasons for selecting varieties suitable for growing in this country and for propagating such varieties by grafting ; the more important characteristics to look for in selecting varieties and a list of the most promising varieties under test are given.

Fruit Group Excursion to Trodger's Way Orchard. A. BERYL BEAKBANE. R.H.S. Fruit Year Book, 1947, 91-4. (E260.)

A popular account of the visit to Trodger's Way Orchard, with special reference to the intensive methods of apple and pear cultivation employed there.

Renewal and Established-spur Pruning of Mature Apple Trees : A Progress Report. W. S. ROGERS and A. P. PRESTON. Rep. E. Malling Res. Sta. for 1946 (1947), 49-54. (E261.)

A Soil Survey of the New Bradbourne Experimental Orchards. A. P. PRESTON and D. J. STANTON. Rep. E. Malling Res. Sta. for 1946 (1947), 55-61. (E262.)

" Green Blotch ", an Abnormal Tissue of Apple Fruits Probably Associated with Spring Frost. IRENA MODLIBOWSKA. Rep. E. Malling Res. Sta. for 1946 (1947), 62-5. (E263.)

Some New Dessert Apples Bred at East Malling. H. M. TYDEMAN. R.H.S. Fruit Year Book, 1947, 27-30. (E267.)

Written principally for the amateur gardener, this paper gives an account of the work being done at East Malling in raising new dessert apple varieties for particular purposes and seasons. The varieties—Tydeman's Early Worcester, Harvest, Michaelmas Red, Martinmas, October Pippin and Late Cox—are briefly described.

Report on Fruit Plant Nurseries and Fruit Research Stations in Western Germany and the German Official Fruit Plant Certification Scheme. W. S. ROGERS and R. J. GARNER. Final Report British Intelligence Objectives Sub-Committee 1072, Item 22 (1947) 17. (E268.)

The authors report upon their visit to Western Germany in November-December, 1945, when they inspected fruit plant nurseries with a view to their utilization for food production without involving the destruction of stocks of valuable material. Horticultural research stations were also inspected and note taken of work carried out during the war. The German nursery inspection and certification scheme is explained and criticized.

Anatomical Studies of Stems and Roots of Hardy Fruit Trees. IV. The Root Structure of some Clonal Apple Rootstocks Budded with Cox's Orange Pippin. A. Beryl Beakbane and Eleanor C. Thompson. J. Pomol., 1947, **23**, 206-11. (E269.)

1. An account is given of the structure of the roots of thirty-eight new clonal apple rootstocks and of nine Malling rootstocks used as controls.

2. Data on the percentage of bark in roots of a given size indicated that there was a correlation between this percentage in the roots produced by a given rootstock and the vigour and precocity of the scion grafted on the rootstock. Further data on different sizes of roots indicated that, (i) there was a relationship between root size and percentage bark, and (ii) this relationship differed with different rootstocks in that the percentage bark decreased more rapidly with increasing size of root in the vigorous than in the dwarfing rootstocks.

3. The structure of the wood of the rootstock roots, in particular the amount of fibre elements and ray cells, was shown to be related to the vigour and fruitfulness of the scion variety.

4. The percentage area of living tissue in the wood and bark of the root together was found to be related to the vigour and fruitfulness of the scion variety.

Spacing as a Factor Governing Rooting and Growth of Hardwood Cuttings of the Myrobalan B Plum Rootstock. R. J. Garner and E. S. J. Hatcher. J. Pomol., 1947, **23**, 149-66. (E271.)

1. Experiments to investigate the effect of spacing on the growth and form of young plants derived from hardwood cuttings of the Myrobalan B plum, *Prunus cerasifera* Ehrh., rootstock are described.

2. On two soils of contrasting features, a normal loam and a highly specialized lake-bed soil, close spacing resulted in plants of smaller general size, with reduced branching, without reduction in the percentage establishment of the cuttings.

3. Marked effects, due to soil and seasonal climatic conditions, were also observed, the plants on the lake soil being considerably more branched than those on the loam.

4. Irrigation of the loam throughout the growing season failed to produce the much branched form of plant typical of the lake soil.

5. The horticultural value of these effects of spacing is considered.

(See also IV. K72 ; IX. E252, F45 and T2.)

In Relation to Small Fruits.

Progress in Strawberry Culture. W. S. Rogers. Rep. E. Malling Res. Sta. for 1946 (1947), 149-50 ; Fruitgrower, 1947, **103**, 79-80 ; Grower, 1947, **27**, 79-80. (Esf57.)

Developments in the Isolated Block System for Raising Strawberry Runners. W. S. Rogers. Rep. E. Malling Res. Sta. for 1946 (1947), 66-73. (E264.)

Root Studies. XI. Raspberry Root Systems. J. R. Christensen. J. Pomol., 1947, **23**, 218-26. (E270.)

Detailed excavations of the rootsystems of mature plants of the raspberry varieties Norfolk Giant, Newburgh and St. Walfried are described and illustrated.

The roots grew at varying depths, ranging from 5 to 175 cm. About 70 per cent. of the total root weight was in the upper 25 cm. of soil.

The maximum root length recorded was 180 cm. Suckers may arise from great depths. Attention is called to the importance of wide separation of plants in variety trials.

(See also IX. T1 and T5.)

Meteorology.

Weather Conditions during 1946. H. M. Tydeman and A. P. Preston. Rep. E. Malling Res. Sta. for 1946 (1947), 74-6. (H48.)

Miscellaneous.

The Experimental Farm. Section I. By F. H. Villiers, with contributions from F. H. Beard, D. H. Hammond and R. J. Garner. Rep. E. Malling Res. Sta. for 1946 (1947), 11-15. (E265.)

General Review of Research Work, with Lists of Papers Published During the Year. Section II. Rep. E. Malling Res. Sta. for 1946 (1947), 16-48. (E266.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN and S. C. PEARCE.

Records.

With the passing of war conditions it has been possible to keep some of the files elsewhere and so relieve pressure on the now over-crowded Records Office. Summaries have again been called for to review the results of long-term trials, the extra work having been successfully handled by the regular staff. The logarithms of trunk girth have now been summarized for some of the more important trials. These new summaries have already repaid the work involved by the consequent saving of time spent in analysis.

Variation Studies.

The investigation into the variation in the incidence of Red Spider mite has yielded results that are now being applied in the interpretation of counts of mites and eggs from the trials in Essex.

A detailed enquiry has been made into the long-term variation of apple trees. This has enabled the changes in variability throughout the life of trees in a trial to be traced and associated with different stages. Information has thus been obtained on the best adjustments to be made to growth and cropping data to correct for the past history of the trees and also on the probability of a trial that has previously shown no significant results doing so in the future because of reduced variability.

In collaboration with the Pathology Section and Wye College, the investigation has been continued on the incidence of Verticillium Wilt in relation to the mineral composition of the plants and the soil in affected hop gardens (see VIII B).

Recording Technique.

Final tree weights obtained on the completion of more trials have been used for comparison with various other measures of tree size. It now appears that a single measurement of trunk girth is very inadequate, because it takes no account of the balance of the tree's activities between extension growth and cambial division. Several measures of this balance have been suggested and are being tried. This work has been extended to include dwarf pyramids as well as bush trees.

Experimental Design.

Developments in the planning of horticultural field trials from 1919 to the present day have been reviewed (see p. 88 of this Report).

In some trials, practical considerations have made it impossible to allot the treatments to the experimental plots completely at random. This may destroy the basis of the customary method of analysing the results. An empirical investigation into the analysis of certain designs where complete randomization has been impossible has not up to the present given any very useful results. However, it has led to a theoretical investigation which has proved very fruitful in suggesting how restrictions should be applied and how to analyse the results obtained.

In designing trials for the comparison of new varieties difficulties sometimes arise on account of the varying numbers of plants available. For randomized block designs, it appears that a variety of which there is an excess may validly be substituted on certain plots for another of which there are insufficient plants available. Also, if two plots have their treatments interchanged, the design remains valid.

Trials have been designed to investigate the reasons for heterogeneity of material used in fungicide trials.

Statistical Technique.

A study, with a view to significance tests, has been made of the quantities, B and I, used as measures of biennial bearing. In this way it is hoped to be able better to detect limited tendencies to this habit.

With perennial species the chances of losing plants during the course of an experiment are by no means negligible. A report has been prepared on the treatment of incomplete data when it is desired to adjust the field results by the method of co-variance and also on the effect of lost data in split-plot designs. Formulae have been derived for calculating significant differences when some plots are missing from a randomized block design.

In order to obtain the best interpretation possible of the data, alternative methods of analysis are under consideration for field trials (i) where the distribution of the quantities examined is of unknown form and (ii) where there are many factors and interactions to be studied, not all of which are relevant to the main purposes of the trial.

The appropriateness of treating the results of some bactericide experiments by methods analogous to those commonly used for biological assays is being tested.

Publications during the Year.

The Measurement of Fruit Crops by Sampling. S. C. Pearce. Rep. E. Malling Res. Sta. for 1946 (1947), 77-82. (M1.)

III. PLANT PHYSIOLOGY*

By M. C. VYVYAN

A.—Vegetative Propagation. (See also I A.)

Cuttings.

A paper published in this Report (p. 117) describes further experiments on the factors controlling the rooting of hardwood cuttings of fruit tree rootstocks, including successful treatment with synthetic growth substances and the use of the " concentrated dip " method of application.

The nutritional aspect, operating through the physiological condition of the parent plants from which the cuttings are taken, represents another very important phase of the problem, and is being developed in various ways. So critical do we consider the source of the cutting, that the culture of parent plants under optimal conditions for providing cuttings has become a primary aim of our nursery technique.

The results of spacing trials with hardwood cuttings of Myrobalan B have been published (E271). These have directed attention to various growth problems and a full analysis of cutting growth has been planned with particular focus on the early establishment period.

B.—Shedding of Fruits, Blossoms and Leaves.

1. Field Trials.

A paper has been published (F46) on the results of the 1946 trials of sprays of NAA (α-naphthalene-acetic acid) for the control of " July Drop " in Cox's Orange Pippin and the pre-harvest drop in Worcester Pearmain, and the after-effect of this spray on the storage behaviour of fruits of Barnack Beauty.

2. Intensive Trials.

A paper on page 121 of this Report describes an intensive method, using alcoholic solutions, and a small-scale spraying method for testing the effectiveness of a number of synthetic substances in delaying abscission, and also a technique by which lanolin emulsion can be quantitatively applied to the plant in small amounts.

Three papers on the results of 1947 trials are published in this Report. These deal respectively with :—(a) the effect of NAA, either applied alone, or mixed with routine June insecticide, on the " July Drop " of Cox and Worcester ; (b) the effect of sprays of 2, 4-dichloro- and 2-methyl-4-chloro-phenoxy-acetic acid on drop in Bramley's Seedling ; and (c) the relative effects of an NAA spray and the date of picking on the subsequent behaviour of stored fruits of Conference pear.

C.—The Abscission Process.

Material for sectioning was collected from Cox and Bramley from the time of bud-break until harvest. As there was enough material left over from previous years covering the general development of the abscission layer, this year emphasis was laid rather on collecting material treated experimentally in various ways.

D.—Hormone Relations.

1. General Survey in Fruit Trees.

Further observations have been made on the auxin relations in shoots of apple and plum varieties and a progress report is published on p. 113. As facilities allow, this survey will be extended to examine particular fruitgrowing problems in which there may be a hormone mechanism involved.

2. Avena coleoptile technique.

The new underground " coleoptile chamber ", for the growing of seedlings under controlled temperature and humidity, has been in operation for most of the year, and the additional facilities have been fully used. As well as the auxin survey of the fruit tree, tests have been carried out by, and for,

* Members of Staff of the Research Institute of Plant Physiology, Imperial College of Science and Technology are working in collaboration with this Section.

other workers engaged on other problems. Techniques have been reviewed, and the Avena seedlings, previously grown individually in small glass specimen tubes, are now grown collectively in zinc trays. The two chambers now operate as a single unit, with the old chamber as the planting room and the new one as the test room.

In April a member of the staff engaged in this work visited the laboratory at Utrecht where much of the early auxin work was carried out.

Publications during the Year.

Use of Sprays to Control Fruit Drop, Especially that of Young Fruit of Cox's Orange Pippin. M. C. Vyvyan and H. W. B. Barlow. Rep. E. Malling Res. Sta. for 1946 (1947), 83-7. (F46.)

(See also I. E271.)

IV. BIOCHEMISTRY

By W. A. ROACH.

During the year work was concentrated mainly on evolving reliable analytical methods for elements in plants and the use of these and plant injection for a preliminary study of the effects of soil, manuring and rootstock on the nutritional status of fruit trees.

Analytical methods for elements in plants.

Chemical.

The search for reliable rapid methods applicable to small samples (about 100 mgr.), desirable for a number of reasons, has been continued along the lines already indicated (K66) and progress has been made, particularly in respect to nitrogen, phosphorus, potassium, calcium, magnesium, iron and boron.

Satisfactorily reproducible results have been obtained on given solutions of plant ash; but reproducibility has not been so satisfactory when working on different samples of the same dried plant material. The difficulties of obtaining reproducible ash solutions are widely recognized and work is in hand to discover and eradicate the causes of these aberrant results. In order to work on a small sample it is essential to avoid the strongly acid solutions obtained with the wet ashing procedure and all the elements, except nitrogen, are determined in a dilute acid solution of the ash obtained by heating the plant material in a muffle furnace controlled at 420-450° C. The ash is usually not completely soluble and it has been confirmed that the residue, the quantity of which varies with the source of the plant material, occludes appreciable amounts of some of the elements, especially iron. In order to avoid this source of error, the residue is removed by centrifuging and fused with 2-3 mg. sodium carbonate in a small depression made in a piece of platinum foil. This operation takes only a few minutes and is not a serious hindrance. The melt is treated, when cold, with dilute hydrochloric acid and the silica, which is again precipitated, does not then contain any appreciable quantities of the elements sought. The silica is separated in the centrifuge and the clear liquid added to the main solution.

It was found that better results are obtained for iron when the acid solution of ash is allowed to stand overnight. This may be due to the hydrolysis of non-ionizable iron compounds.

Work has been continued on the estimation of potassium by a photoelectric nephelometric method, using a sodium cobaltinitrite suspension in alcohol. Encouraging results are being obtained on volumes as small as 0·1 ml. A selenium type photoelectric cell of 25 mm. diameter is being used and the current output measured, using the Campbell-Freeth circuit. The optical cell stands on the photoelectric cell and is illuminated from the side. The optical cell consists of a glass capillary tube sealed into a flat-bottomed glass tube containing redistilled carbon disulphide (refractive index 1·627). Much of the light scattered by the suspended particles in the capillary tube is " trapped " within the cell and a high proportion escapes only through the base of the tube and passes out into the photoelectric cell.

There is no further progress to report at present on the estimation of copper and zinc.

Some work has been done during the year on rapid methods of drying plant material.

Spectrographic.

The flame method of spectrographic analysis published last year has been improved both in respect of reproducibility and sensitivity. The interference of certain elements with the line densities of others is being studied. The interference of phosphorus and silicon with calcium, magnesium and iron is so serious that it must be eliminated or controlled before even approximately accurate values can be obtained for these elements.

This method, however, continues to give preliminary diagnoses that are borne out by the results of curative treatment.

An arc method of spectrographic analysis is being developed.

Fractionation of nutrient elements.

Work, started in 1940, has been taken up again on the selective extraction of leaf material with a series of organic and other solvents as a preliminary to mineral analysis. The aims are to separate the fractions of the elements that are present in forms useless to the plant from those that are of value to it. and to separate the latter according to their state of chemical combination. The possibility of separating by this means elements that interfere with each other in mineral analysis is also being investigated.

Effects of soil, manuring and rootstock on the mineral status of fruit trees.

Some preliminary results were given in the Report for 1946 (K66). An extensive series of samples taken in 1947 is being analysed. An extremely heavy red spider attack during the season interfered seriously with diagnosis by leaf injection.

Physiological Effects of Trace Elements*

Physiological investigation of the effects of manganese on plant growth was continued. Manganese deficient material was obtained by growing potato plants, both in pots and in the field, on the manganese deficiency producing soil from the Bradbourne lakebed.

For experimental purposes the manganese level in these plants was artificially increased either by means of the Roach leaf-stalk injection technique or by spraying with a dilute solution of manganese sulphate.

In a series of assimilation experiments, using a new modification of the Sachs half-leaf technique developed at East Malling, in which the manganese level of the experimental leaflets was raised by injection, no effect of manganese in increasing photosynthesis was obtained. A significant effect of manganese in increasing the dry-weight per unit area of the injected leaflets over that of the controls four days after injection was, however, found. The interpretation of this effect is at present obscure (see p. 126 of this Report).

Spraying experiments carried out on the lakebed showed significant increases of 26·5 per cent. and 36·4 per cent. in mean tuber number and mean yield per plant respectively as a result of manganese treatment.

A significant effect of manganese spraying in increasing height was also found in experiments with pot plants.

Chemical analyses show that the manganese content of the experimental material was successfully increased by both injection and spraying.

Publications during the Year.

Multiple Mineral Deficiencies in Fruit Trees. Injection as a First Aid Treatment. Winifred O. Roberts and N. Landau. J. Pomol., 1947, **23**, 80-91. (K63.)

Solid injection was used experimentally as a first-aid treatment to combat a serious and widespread attack of die-back in apple trees due to multiple deficiency of potassium and one or more of the trace elements manganese and iron. Experimental injections of the necessary nutrients into apple trees brought about an improvement in foliage colour and an increase in the potassium content of the leaves. Injection of the deficient trace element alone seemed to bring about an even greater increase in the potassium content of the leaves and the injection of a deficient trace element plus a potassium salt led to a greater increase in potassium content than that following the injection of a potassium salt alone. Injections of manganese salts alone or combined with a potassium salt caused an increase in the manganese content of the leaf.

Preliminary Experiments on the Injection of Individual Apple Fruits on the Tree. B. F. G. Levy. J. Pomol., 1947, **23**, 134-6. (K64.)

In preliminary experiments with dye solutions individual apple fruits were injected whilst on the tree.

Injection through the cut end of a leafy shoot arising near the base of a bourse bearing a fruit resulted in total permeation of that fruit.

Injection through a secondary shoot arising on the same bourse as the fruit, resulted in the permeation of one or two sectors of the fruit only.

The injection of nutrient solutions by either of these methods should prove of use in the study of physiological disorders in trees in the field.

The Use of Leaf Analysis, Plant Injection and Curative Treatment for the Determination of Mineral Deficiency in plants. W. A. Roach. Ann. appl. Biol., 1947, **34**, 153-9. (K65.)

A brief description of the use of three methods of diagnosis and of some of the results already obtained. It was emphasized that diagnoses based on the first two methods were only preliminary. A final diagnosis could only be based on the effects of curative treatment on yield and quality of crop. The measurement of the effect tends to be very complicated when plants are affected by several deficiencies because there are in some cases strong interactions between the effects of the various elements.

* This work is being carried out by members of the Staff of the Research Institute of Plant Physiology, Imperial College of Science and Technology, working in collaboration with the Biochemistry Section.

The Role of Mineral Nutrition in the Rootstock-Scion Effect. A Progress Report. W. A. Roach. (Appendices on methods of analysis by A. C. Mason and F. H. Vanstone.) Rep. E. Malling Res. Sta. for 1946 (1947), 88-94. (K66.)

Suspected Boron Deficiency in Apples in Britain. B. F. G. Levy. Rep. E. Malling Res. Sta. for 1946 (1947), 95-8. (K67.)

Tree Injection I. The Estimation of Dosage in Relationship to Tree Size. B. F. G. Levy. Rep. E. Malling Res. Sta. for 1946 (1947), 99-103. (K68.)

Tree Injection II. Methods for Overcoming Resistance to Absorption of Liquids. B. F. G. Levy. Rep. E. Malling Res. Sta. for 1946 (1947), 104-6. (K69.)

Tree Injection III. Re-invigoration of Debilitated Trees. B. F. G. Levy. Rep E. Malling Res. Sta. for 1946 (1947), 107-12. (K70.)

Plant Injection Methods. W. A. Roach. Paper read to N.A.A.S. Revision Course, September, 1946. Published in report " Papers Read at the Revision Course in Horticulture to members of the National Agricultural Advisory Service, 3rd-7th September, 1946 ", by the School of Agriculture, University College, Nottingham, 1947. (For private circulation.) (K71.)

A brief description of plant injection methods and of the results already obtained by the use of those methods in conjunction with plant analysis and the measurement of the effect of curative treatment on yield and quality of crop. The overriding importance of this measurement of the effect of treatment was stressed.

Examination (After Injection With a Dye) of a double-worked plum tree showing incompatibility. W. A. Roach and Eleanor C. Thompson. J. Pomol., 1947, **23**, 212-7. (K72.)

A double-worked plum tree, Victoria/President/Myrobalan B, showing signs of incompatibility in one of its two branches more than in the other, was injected with a dye solution.

The framework of the tree was sawn and split to study the distribution of the dye, the structure of the unions and the distribution of heartwood.

A visible deterioration of the union was found to correspond with the removal of all the President foliage, but the health of the tree was not affected until all woody tissues formed previous to this had become changed into heartwood, rendering the tree dependent on the later imperfectly formed part of the union. The transformation to heartwood had progressed further in those tissues in direct connection with the unhealthy branch than in those supplying the healthy one.

V. PLANT PATHOLOGY

By R. V. HARRIS

A.—Bacterial Diseases.

Bacterial Canker of Stone Fruits (*Pseudomonas* spp.).

Previous work had shown that the amount of damage to the tree must depend largely on the number of the disease organisms present, and in 1947 a detailed investigation was therefore made of the conditions *in vitro* (glass-tube cultures) necessary to produce large populations of the bacterial cells. This has revealed certain critical factors which determine their rate of multiplication and the maximum number of cells which can exist in a given volume, and the possibility of these factors operating in the living tree will now be examined.

Some field work on bacterial leaf spot scheduled for the summer had to be postponed owing to the non-appearance of this phase of the disease, but an attempt at a survey of the bacterial population of the surface of the bark through the spring and summer to autumn met with unexpected success in spite of the primitive methods employed. As a result of the indication of a higher number of bacteria in one particular site, the probable source of inoculum for the leaf spot phase of the disease was found.

The comparison of bactericides on sweet cherry was continued, and natural infections were more numerous in 1947 on the trees of the trial plot, so that conclusions can more readily be drawn. Home-made Bordeaux mixture has so far proved the most effective specific against this disease.

B.—Fungus Diseases.

1. Cherry Scab.

Following recent observations, experiments were made to determine details of the seasonal cycle of the pathogen (*Fusicladium cerasi* (Rabenh.) Sacc.) in relation to the formulation of control measures, but so far the results are inconclusive.

2. Verticillium Wilts. (See also VIII. B.)

(*a*) *Strawberry.*—Further observations on wilt incidence were made in the Wisbech area and other districts in collaboration with the appropriate advisory officers and experiments on the incidence of the disease in infected and healthy runners on diseased and healthy sites were concluded. Trials of wilt resistance have been conducted which indicate that no commercial variety possesses appreciable resistance in soil heavily infected with *V. albo-atrum*. The results from these trials are to be published shortly. A further trial was laid down on a plot of naturally infected ground to determine the effect on the disease of prior cropping with potatoes, mangolds, peas and clover ley. These crops having been harvested, the plot was planted with strawberries, for observation in 1948.

(*b*) *Other hosts.*—The experiments on wilt incidence in other hosts were continued. A particular study is being made of the effect of *V. albo-atrum* and *V. dahliae* on the potato and the " carry over " of the disease in the tubers. No success has yet been achieved in the search for a host other than the hop which will act as an indicator of the relative virulence of the progressive and fluctuating strains of *V. albo-atrum*. Work in connection with recently observed severe cases of wilt in raspberry plantations was also continued.

(*c*) *Laboratory studies.*—Experiments were started to investigate the growth and persistence of Verticillium in the soil and the effect on it of other soil micro-organisms. Culture studies of *V. dahliae* were also started with a view to classifying isolates obtained from various sources, and a large culture collection of this fungus and *V. albo-atrum* is being built up.

3. Rubus Diseases—Raspberry Cane Blight. (See also VI. B. and Report of A.R.C. Scottish Raspberry Investigation.)

The study and identification of fungi associated with this disease were continued in conjunction with the Entomological studies (q.v.) and the pathogenicity of many isolates from cane blight lesions was shown to be of a low order.

The generally accepted pathogen, *Leptosphaeria coniothyrium* (Fulk.) Sacc., was absent from local plantations during 1947, but was much in evidence on Newburgh raspberry in Surrey. Similarly, a species of *Phoma* associated with cane blight lesions was absent locally, but appeared in quantity near Canterbury. Two species of *Fusarium* were common in most plantations, one doing considerable damage, particularly to Newburgh, although neither this fungus nor the *Phoma* sp. caused lesions

comparable in severity to those of *L. coniothyrium*. The *Phoma* sp. appears to be a stage of *Didymella applanata*, the cause of Spur Blight, and a study of the factors determining the different types of lesion was started.

A survey of the surface flora of the cane at different heights showed the presence of pathogenic fungi before midge attack, and an investigation of the ability of adult and larval midge (*Thomasiniana theobaldi*) and of slugs and snails to carry fungi showed that the adult midge does carry fungi, while it is improbable that the larval stage does so at all. Slugs and snails do so internally and are not likely to do so externally.

C.—Virus Diseases of Fruits. (See also VIII. B.)

1. Strawberry.

Work on the separation of strawberry virus complexes has now shown that the position is more complicated than was at first thought. At least five, and probably six, viruses are involved. Methods for the separation of one of these have already been described and an account of work on the separation and some properties of the second and third is in the press.

The importance of the fourth virus is at present uncertain, but it is common in commercial strawberry stocks. It differs from the others in that *Fragaria vesca* appears to be tolerant to it and does not exhibit clear symptoms when infected. The fifth virus has, so far, been isolated only from a plant of an American variety. Its frequency in Great Britain and its importance in strawberry cultivation are unknown.

Later work on Virus 2 (isolated from plants infected with Yellow-edge) suggests that Virus 2 is itself a complex of two viruses and thus, if this proves to be correct, no fewer than six viruses are able to infect strawberry.

Work on the graft testing of samples of strawberry plants of different varieties and the selection of virus-free individuals has been continued. During 1947 a number of samples were so tested and five plants selected for propagation and pomological trial.

There is some evidence that clones already released are slowly becoming re-infected under field conditions, despite the inspection and certification of such stocks under the Ministry's Special Stocks scheme. This was, of course, to be expected, but it is intended to investigate the position in more detail so that fresh issues of tested clones may be recommended when required.

2. Raspberry and Other Rubus sp. (See also A.R.C. Scottish Raspberry Investigation.)

Tests of four new seedlings showed that all of them were substantially virus-free and that three were tolerant and one sensitive to Mosaic 2.

An outbreak of Dwarf, a disease previously largely restricted to phenomenal berry and blackberry, was reported in 1946 on loganberry. During 1947 a disease producing similar symptoms on some varieties of raspberry was observed (see also I.B.). Experiments were started to determine, *inter alia*, whether the disease in raspberry can be controlled by drastic roguing; whether the pathogen in raspberry Dwarf is the same as that in loganberry and phenomenal berry Dwarf; and the identity of the vector.

3. Tree Fruits.

Stony pit of Pears. Mature pear trees were grafted in April, 1946, with scions from trees showing symptoms of stony pit, but there was no indication of transmission of the disease in 1947. These trees have since been grubbed, but other small-scale experiments are in progress.

Preliminary experiments on Apple mosaic, Rubbery wood and Chat fruit are in progress.

D.—Problems of Disease Control.

1. Tests of Fungicides on the Host Plants. (See also VI and VII.)

(*a*) *Mass Infection Methods.*—Experiments on methods for providing diseased host material for test purposes by large-scale aided infection in the open were continued as follows.

Apple Scab (*Venturia inaequalis*).—After several unsuccessful attempts, severe infection was obtained on unworked apple rootstocks in three experiments, two of them made under the exceptional drought conditions of the summer. A progress report was published (C225) in which the problem is reviewed and the methods adopted briefly outlined. If consistent results are forthcoming in other seasons the method should prove a valuable adjunct to the process of testing new fungicides, and possibly in determining the relation between manurial treatments and disease incidence.

Apple Canker (*Nectria galligena*).—Attempts are being made to find a spray programme for the control of this disease, which at present must be controlled chiefly by the laborious process of canker

excision. Two field spraying trials, in one of which inoculum was provided, have been completed and have shown conflicting results. Unless this work can be done on canker-susceptible trees in a locality favourable to the disease, progress by field trial is likely to be very slow. Experiments were therefore developed in the mass-infection of unworked apple rootstocks with this disease and others were designed to elucidate the normal period of natural infection in field plantations. Promising results were obtained.

(*b*) *New Fungicides.*—The investigation of phenyl mercury chloride (p.m.c.) as a fungicide was continued in the field, various formulations of the basic substance again being compared against Apple Scab. (See also VII. B.) Though promising, neither of two well-known commercial formulations at recommended dilutions (= 0·005 per cent. p.m.c.) was as effective as a full schedule of lime-sulphur sprays as recommended in the Spray Calendar, though the results of the trials suggest that they may prove to be useful substitutes for certain of the constituent lime-sulphur applications. Prospects were greatly improved when the formulation based on china clay was tested at 0·01 per cent. p.m.c.

2. The Control of Brown Rot (*Monilia fructigena*).

Apple.—The relationship between the incidence of Brown Rot and the presence of wounds caused by insect, fungus, and mechanical agencies was confirmed in the field by comparing spray programmes from each of which a different specific against a pest or disease was in turn omitted. The relative importance of each wound agent has thus been determined.

Cobnut and Filbert.—A similar relationship has been established on these hosts. The Brown Rot fungus has proved to be the chief pathogen involved and Nut Weevil (*Balaninus nucum*) the chief wound-agent. On this basis work was started in conjunction with the Entomology Section (see VI. A), to determine means of control. Early results from this work have been promising, and a brief account of the evidence for Nut Weevil as a precursor of fungus attack (*M. fructigena* and *Botrytis cinerea*) was published. (C226.)

On these hosts the use of fungicides proved ineffective as a direct means of controlling the disease ; insecticides were, on the other hand, very promising.

Publications during the Year.

Notes on Varieties of Hop Resistant to Verticillium Wilt. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1946 (1947), 157-9. (C222.)

Verticillium Wilt of the Hop (*Humulus lupulus*). II. The Selection of Wilt Resistant Varieties. W. G. Keyworth. J. Pomol., 1947, **23**, 99-108. (C223.)

A description is given of the methods by which hop varieties have been selected for resistance to Verticillium Wilt and further tested in commercial gardens. The tests have shown that some of the Wye varieties and one variety bred on a commercial farm possess marked resistance to the disease.

A Review of Some Recent Research on Virus Diseases of Raspberry and Strawberry in Great Britain. R. V. Harris. Rep. E. Malling Res. Sta. for 1946 (1947), 113-7. (C224.)

Apple Rootstocks as an Outdoor Host for Mass Infection and Fungicide Testing. M. H. Moore. Rep. E. Malling Res. Sta. for 1946 (1947), 118-9. (C225.)

Preliminary Report on *Monilia fructigena* and *Botrytis cinerea* as wound parasites of Cobnuts and Filberts. M. H. Moore. Rep. E. Malling Res. Sta. for 1946 (1947), 120-1. (C226.)

Mosaic Disease of the Hop. A Study of Tolerant and Sensitive Varieties. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1946 (1947), 142-8. (C227.)

Improving the Field Performance of Standard Fungicides. II. The Use of Ferrous Sulphate to diminish spray damage on apple. M. H. Moore. J. Pomol., 1947, **23**, 139-48. (C228.)

The addition of ferrous sulphate to lime-sulphur at 1-60 applied post-blossom with or without lead or calcium arsenate greatly reduced early spray-induced leaf-drop present on apple varieties Cox's Orange Pippin and Worcester Pearmain, but failed to prevent, though mitigating, severe fruit-drop on both varieties. There was no evidence that the addition impaired the fungicidal value of the combined spray. Calcium arsenate powder (0·4 per cent.) proved more phytotoxic than lead arsenate paste (0·4 per cent.) of much lower As_2O_5 equivalent. With lime-sulphur at 1-100, the paste and a colloidal form (0·4 per cent.) were each rather less phytotoxic on Cox's than a powder form (0·2 per cent.) of double As_2O_5 equivalent. The addition of ferrous sulphate to the combined spray prevented early leaf-drop on Cox, but failed substantially to prevent fruit-drop, and also depressed acaricidal value. Zinc sulphate was an unsatisfactory alternative to ferrous sulphate. Worcester proved much less susceptible than Cox to spray damage, most of which was caused by the second post-blossom (June) application.

VI. ENTOMOLOGY

By A. M. MASSEE.

A.—Tree Fruits.

Apple Blossom Weevil (*Anthonomus pomorum*).

Good control has been obtained by adding DDT to tar oil, D.N.C. and petroleum sprays respectively. (See VII. B.)

Woolly Aphid Parasite (*Aphelinus mali*).

The over-wintering of the Woolly Aphid parasite under apple gas storage conditions, in the winter of 1946-7 was once again successfully undertaken. The parasites were introduced into infested orchards the following June and vigorous colonies were established.

Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch).

The special investigations are being continued at the Field Laboratory, Great Braxted, Essex, and complementary studies are being undertaken at East Malling.

A study of the life-cycle is being continued under Essex conditions and a complete picture of the habits of the mite has been obtained. The beneficial predators associated with the mite are also being investigated and the life-cycle and habits of the more important species are being worked out.

Further observations have been made on the migratory phase of the mite and further data upon the movements of the mites during the summer months are being accumulated in Kent and Essex.

Field Spraying Trials.—Spraying trials have been carried out for the fourth year and sufficient data have been obtained to make specific recommendations for the control of the winter egg stage of the mite. (See VII. B.) A popular account of this work (D203) and a scientific report (D204) have been published.

Field and laboratory tests of insecticides on the eggs and mites of the Fruit Tree Red Spider mite are in progress as a preliminary to the field trials now being made. (See VII. A.)

The Effect of DDT upon Beneficial Insects Associated With Fruit.

Observations are being made on the effect of DDT upon beneficial, predaceous, parasitic and pollinating insects associated with fruit. The " build-up " of harmful insects as the result of using DDT at certain periods of the year is also being investigated in the field.

Apple Capsid Bug (*Plesiocoris rugicollis*).

Field spraying trials have been continued to compare early and late applications of ovicides against this insect.

Nut Weevil (*Balaninus nucum*).

A study of the life-cycle of this important nut pest is being continued. Control measures are also being worked out in the field and very successful preliminary trials have been made. The association of the nut weevil with premature nut drop has been established and a very interesting story is being unfolded. (See V. A.)

B.—Small Fruits.

Strawberry Blossom Weevil (*Anthonomus rubi*).

Collaboration with the N.A.A.S. has enabled field experiments to be carried out in Hampshire in an effort to control this pest with 5 per cent. DDT dust.

Strawberry Aphid Control by Insecticidal Smokes.

Aphid populations were so low following the extremely severe winter that very little work has been possible. A Campbell Nicotine Fumigator has been kindly loaned by the makers.

Control of Strawberry Tarsonemid Mite (*Tarsonemus pallidus*).

In collaboration with workers at the Imperial College of Science methyl bromide is being tested as an alternative to the warm water treatment. Phytocidal tests are complete and preliminary experiments against the mite have given promising results.

Strawberry Eelworm (*Aphelencoides fragariae*).

Potted plants have been inoculated to observe symptoms and test possible methods of control.

Fauna of Cultivated Strawberries.

Only one addition during 1947 suggests the list is nearing completion.

Vine Weevil (*Otiorrhynchus sulcatus*).

Various insecticides are under test to discover means of eliminating larvae from potted plants.

Study of Aphides Associated with Top and Soft Fruits.

Biological studies are in progress. The help of systematists is being sought to disentangle the nomenclatural problems.

Raspberry Cane Midge (*Thomasiniana theobaldi*).

Population counts have shown that a large increase in numbers may be expected between May and August. The distribution of this population on the canes and the nature of its attack at various stages of cane growth have been studied.

In collaboration with Plant Pathology Section a study has been made of the circumstances in which fungal invasion follows midge attack. (See I. B and V. B, 3.)

Similar midges have been found on various wild host plants and the biologic relation of these and the Red Bud Borer to the Raspberry Cane Midge is being investigated.

Field trials of various soil treatments have so far failed to give an adequate degree of control. Laboratory trials of other substances have shown more promising results.

Red Bud Borer (*Thomasiniana oculiperda*).

Observations are being made on the biology of this midge and its relation to the Raspberry Cane Midge.

Black Currant Leaf Curling Midge (*Dasyneura tetensi*).

Observations are being made on the life history of this insect and an experiment on its control has been carried out.

Systematic Study of Phytoptidae and Tetranychidae.

A study of the species contained in these two groups of mites is being made when time permits.

Publications during the Year.

The Strawberry Rhynchites and its Control. G. H. L. Dicker. Rep. E. Malling Res. Sta. for 1946 (1947), 151-3; Grower, 1947, **27**, 391, 393-4 and 423-5; Fruitgrower, 1947, **103**, 297-8. (D196.)

The Spraying Programme with Special Reference to DDT. A. M. Massee. Kent Fmr's J., 1947, **61**, 40-1. (D197.)

A survey of the winter and spring spraying programme indicating when DDT should be incorporated with other routine sprays.

D.D.T. A Survey of its Uses and Limitations Against Fruit Pests. G. H. L. Dicker. Gdng ill., 1947, **64**, 1,085-6. (D199.)

After a brief historical summary it is pointed out that insufficient time has elapsed for the full potentialities of DDT to be assessed. Some of the pests which can be controlled by DDT are mentioned and the point is stressed that indiscriminate use may indirectly encourage pests by destroying their predators and parasites; the Fruit Tree Red Spider is cited as an example.

Control of the Strawberry Rhynchites (*Rhynchites germanicus* Herbst) **with Notes on its Biology.** G. H. L. Dicker. J. Pomol., 1947, **23**, 63-70. (D200.)

Rhynchites germanicus Herbst overwinters as an adult in the pupal cocoon in the soil, emerging between mid-March and early May. On strawberry, eggs are laid from mid-April to late August in the stalks of young leaves and blossom trusses; also near the tips of stolons. Immediately after oviposition the adult girdles the stalk below the egg cavity, causing wilting and death of the terminal portion. The larva feeds by hollowing the dead tissue and when fully fed burrows into the soil. Other host plants include wild and cultivated blackberry, raspberry, loganberry and phenomenal berry. The economic aspect of attack on these plants is discussed.

From results of laboratory and field trials in 1945 and 1946 it is shown that on strawberries a single application of 3 per cent. or 5 per cent. DDT dust, having a gypsum-china clay base, at the rate of 20-25 lb. per acre, when the first blossom trusses appear, gave excellent control. Three per cent. DDT gave protection for at least a fortnight, whilst no re-infestation was noted up to one month after dusting with 5 per cent. DDT. A 5 per cent. benzene hexachloride ("Gammexane") dust with the same base, appeared to give only slight control.

Both DDT and benzene hexachloride at 5 per cent. reduced the numbers of *Anthonomus rubi* Herbst, but had no effect on the Strawberry Aphis *Pentatrichopus fragariae* Theobald.

A New Method of Rearing the Fruit Tree Red Spider (*Oligonychus ulmi* Koch) **on Apple Seedlings.** A. M. Massee. Rep. E. Malling Res. Sta. for 1946 (1947), 122-3. (D201.)

Notes on Some Interesting Insects Observed in 1946. A. M. Massee. Rep. E. Malling Res. Sta. for 1946 (1947), 124-8. (D202.)

The Fruit Tree Red Spider and its Control. M. D. Austin and A. M. Massee. Fruitgrower, 1947, **104**, 624; Grower, 1947, **28**, 692-3; Gdnrs' Chron., 1947, **122**, 191. (D203.)

A popular account of the details of control of Fruit Tree Red Spider by means of delayed dormant and post-blossom sprays is given.

Stress is laid upon the necessity of timing the applications correctly to obtain best results.

Investigations on the Control of the Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch) **during the Dormant Season.** M. D. Austin and A. M. Massee. J. Pomol., 1947, **23**, 227-53. (D204).

An account is given of a three-year investigation on the destruction of the winter eggs of the Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch) on apple by means of petroleum and D.N.C. washes applied in January, February and March.

1. Biological data relevant to this investigation are discussed.

2. A mite population recording procedure is described.

3. Measures designed to minimize risk due to spray-drift when treatments are applied to randomized blocks are outlined.

4. It is shown that petroleum and D.N.C. washes applied at the same strength, on the same day, inhibit the hatching of a high proportion of the winter eggs, and that the mid-February and March applications give significantly greater egg-hatch reductions than that of January.

5. The results obtained with petroleum and D.N.C. are similar, no significant differences being noted. The addition of D.N.C. to the petroleum wash did not increase the efficacy of the wash.

6. Even when the hatching of 97 per cent. of the winter eggs has been inhibited by these washes, the mites that hatch from the surviving eggs give rise to enormous populations by the late summer and consequently even out any broad differences previously ascribed to any given treatment.

7. Whilst the number of eggs of the first generation on sprayed trees can be correlated with the measure of winter egg destruction, this correlation cannot be made in late summer when the "build-up" of mite populations has compensated for this initial check.

8. The "build-up" of mite populations occurs annually and is considerable, because there are three or more generations a year in this country.

9. It is considered that a programme of winter and summer sprayings will be necessary to achieve commercial control of this pest.

VII. PLANT PROTECTIVE CHEMISTRY

By J. K. EATON.

A.—Laboratory Investigations.

Chemicals.

The standardization of methods for the analysis of pest and disease control materials has continued. This has included the estimation of polysulphide sulphur in certain sulphur preparations.

Further studies have been made of the *in vitro* reactions of the dithiocarbamates. The sodium salts of mono- and di-substituted dithiocarbamates have been shown to crystallize from moist organic solvents with water of crystallization. This observation is proving of value in putting these studies on a quantitative basis.

The estimation of DDT on foliage has been further investigated. The amount of DDT remaining as a residual deposit on the surface of vegetation was found to vary largely with its mode of deposition, the concentration of insecticide in the preparation, and to some extent on the volatility of the solvent. The absorption of part of the insecticide by the leaf tissues was established ; this was not lost by any catalytic action by the leaf tissue and could be recovered by prolonged extraction. The portion of the deposit showing contact toxicity was readily recovered by extraction.

Ovicides.

An examination of the toxicity of a series of organic nitrogenous bases and chlorinated phenols to the eggs of *Aphis pomi* has been completed. Only carbazole, nicotine and phenanthridine showed promise, but were two to three times less toxic than 3 : 5-dinitro-*o*-cresol. None of the phenanthridine derivatives tested retained the toxicity of the parent compound, while of the carbazole derivatives only the 9-nitro and the 3-amino compounds were similar in toxicity to carbazole. None of the chlorinated phenols showed any noteworthy toxicity.

Work on the ovicidal action of organic phosphorus compounds has continued. Hexaethyl-tetraphosphate has little toxicity to *Aphis pomi* eggs, but their marked susceptibility to diethyl-*p*-nitrophenylphosphate has been confirmed. This compound does not, however, appear to be very toxic to eggs of *Operophtera brumata*. On the other hand diethyl-*p*-nitrophenylthiophosphate seems very effective against Winter Moth eggs and rather less toxic to those of *Aphis pomi*.

Techniques for using the winter eggs of the Fruit Tree Red Spider as test-organism have been investigated and a number of organic compounds tested for toxicity.

In collaboration with the Statistics Section, means are being sought, either by modification of experimental design or by selection of material, to reduce the variability in ovicide trials. (See II.)

Acaricides.

A systematic investigation of the toxicity of synthetic and naturally occurring compounds to summer stages (egg and adult female) of the Fruit Tree Red Spider was commenced. The marked toxicity of a Lonchocarpus ground root to the adults and its indifferent ovicidal action was shown and indications obtained of a slight synergistic effect when the Lonchocarpus was applied in conjunction with a highly refined petroleum oil.

Several compounds structurally related to azobenzene were tested to investigate the relation between toxicity and chemical structure. Substitution in the benzene nuclei resulted in a loss of toxicity in all cases tried, while the effect of replacement of the azo-linkage by other atomic groupings varied according to the nature of the grouping and biological stage. Of those tested, azoxybenzene and benzyl benzoate were the only substances whose toxicity to both eggs and adult females compared with azobenzene, while diphenyl sulphone showed the greatest toxicity to the egg stage. Of the other substances tested, dithiocarbamates, simple alkyl sulphides, disulphides and mercaptans showed little toxicity, but a number of thiuram mono-, di-, and poly-sulphides have some ovicidal power, but little toxicity to the adult mites.

Contact Insecticides.

Chemical investigations on the effect of the solvent on the absorption of DDT by leaves have been accompanied and confirmed by a parallel series of biological tests using *Tribolium confusum* as the test organism. These show that the use of a high boiling solvent results in a greater absorption of DDT into the leaf tissue as compared with a volatile solvent and that the absorbed DDT is not available as a contact poison.

Fungicides.

Attention has been directed towards improving the method of estimating fungicidal action. Germinating spores have been assigned values depending on germ tube length and the percentage mortality results modified accordingly. The procedure has served to reduce the apparent variation between tests and the scatter of points about the dosage-mortality curve observed during work on the substituted dithiocarbamates.

B.—Field Investigations.

Insecticide Trials.

Raspberry Beetle.—Further trials of the relative effectiveness of three alternative formulations of DDT, namely emulsion, suspension and wettable powder, showed no significant difference between treatments.

Apple Sawfly.—Applications designed to determine the effect of synthetic compounds on (*a*) the egg stage and (*b*) the newly hatched larvae, showed that hexaethyl tetraphosphate at 0·05 per cent. was ineffective against both, whereas 0·01 per cent. gamma isomer of benzene hexachloride appeared slightly, but not significantly, more effective than the standard nicotine spray (0·05 per cent. at petal-fall).

Fruit Tree Red Spider.—The trials in Essex to compare the efficiency of mid-March applications of miscible and stock emulsion petroleum washes have been completed. The first year's work on a combined winter and early summer spraying trial has been carried out . (See VI. A.) A preliminary phytotoxicity test on azobenzene was carried out in late June. It was found that a 0·1 per cent. suspension or emulsion caused noticeable leaf scorch and some leaf fall on both Cox's Orange Pippin and Laxton's Superb.

Apple Blossom Weevil.—The trials to determine the effectiveness of DDT when incorporated in winter washes have continued. (See VI. A.)

Fungicide Trials.

Apple Scab.—The spraying trial on young Cox's Orange Pippin trees was continued. Phenyl mercury chloride at 0·01 per cent. dispersed with methyl cellulose was fungicidally similar to a sulphite lye dispersion at the same strength; both sprays caused some damage. (See also V. D, 1(b).)

PUBLICATIONS DURING THE YEAR.

The Use of DDT Against Fruit Pests. H. SHAW. Farming Digest, 1947, 2, 25-7. (Q44.)

A popular review of the possible application of DDT in the control of fruit tree pests, with some discussion of its limitations and the precautions necessary in using it.

Development in Methods and Materials for the Control of Plant Pests and Diseases in Germany. H. MARTIN and H. SHAW. Final Report British Intelligence Objectives Sub-Committee 1095, Item 22. (Q45.)

The various German and Swiss research establishments visited are briefly described and their programmes indicated. An account is given of a wide range of synthetic plant protective materials and of " systemic " insecticides developed in Germany during the war. A survey of the pest situation in Switzerland and Germany is given together with control measures adopted.

Laboratory Studies on the Toxicity of Hydrocarbon Oils and Similar Substances to the Eggs of Some Common Orchard Pests. I. General Introduction. II. Experiments on the Eggs of the Winter Moth (*Operophtera brumata L.*). H. SHAW and W. STEER. J. Pomol., 1947, 23, 1-22. (Q46.)

I. The materials, methods and test organisms used in a series of investigations on the toxicity of oils to insect eggs are described. The broad chemical classification of these oils is discussed.

II. A selection of tar and petroleum oils covering a very wide range of chemical types was tested against eggs of the Winter Moth (*Operophtera brumata L.*). The first broad survey showed that of several physical and chemical characteristics determined for each oil, distillation range, especially the content of oil distilling above 300° C., was most closely related to toxicity, but did not wholly explain it. Tests of distilled fractions of the neutral oils showed that for any one oil, toxicity increased with distillation range up to about 400° C., but varied widely between similar distillation ranges of different oils. The petroleum oils in general were much more toxic than the tar oils. Over the range of oils as a whole, though with some exceptions, it appeared that the proportion of aliphatic material in the oil, as judged by the percentage insoluble in dimethyl sulphate, might be a considerable factor in

determining toxicity. Indirect evidence suggested that paraffinic components were probably more toxic than naphthenic. Viscosity seemed to have little connection with toxicity and specific gravity appeared to be connected only within small, closely related groups of oils. The phenols and bases isolated from the tar oils were not sufficiently toxic to contribute materially to the toxicity of the whole oils nor, on the other hand, were they present in sufficient quantity to reduce the toxicity by dilution.

The Formation of Phosgene from DDT and Related Compounds. J. K. Eaton. Rep. E. Malling Res. Sta. for 1946 (1947), 129-30. (Q47.)

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties.

Detailed records on the seven clonal selections of Goldings have been continued. Twenty-seven out of some one hundred Fuggle plants from different sources have become sufficiently established for observational records to be made. Several showed the scorching of the leaves common in the Fuggle hop and more or less split-leaf-blotch and can therefore be rejected. However, fourteen (including five Early Fuggle) had completely healthy leaves and the crop from these was dried separately and samples were saved for analysis. It is hoped to select a few worthy of cropping and brewing trials.

New Varieties.

The crops from ninety-one new varieties raised by Professor E. S. Salmon at Wye were picked and dried separately so that yields could be estimated and, where necessary, samples saved for P.V. determination. Samples of thirty-nine varieties (including the two chief Wilt-resistant varieties) were pressed in separate part-pockets for use in brewing trials. A report on the trial of new varieties for 1946 has been published by Professor Salmon (B59).

Cultural Trials.

The trial of three times of " cutting " the hills, with and without subsequent removal of the most forward bine, has been continued. Red Spider damage was much more severe on the hills " cut " in December and February from which the most forward bine was not removed.

Propagation Trials.

Three reports on propagation trials of 1946 have been published (B60, 61, 62).

Trials designed to measure varietal and seasonal differences in take and size of set produced have been continued with the Goldings and the New Varieties. In 1947 the differences in take between seven clonal Goldings were very great. A comparison of various dates of planting strap-cuts had to be postponed owing to the severe winter. For details of layering trials, see VIII. B.

Other Investigations.

Further data on the amount of pull required to detach the cones of the principal varieties have been obtained. Although the same varieties occupied the extreme positions in both 1946 and 1947, there was considerable variation amongst other varieties in the two seasons. As 1947 was in many ways an abnormal season, further data will be collected before any results are published.

B.—Diseases of Hops.

By W. G. KEYWORTH.

Verticillium Wilt. (See also V. B2.)

(*a*) *Survey*.—Eight outbreaks of Wilt were newly reported to the Research Station from Kent and Sussex during 1947. Of these, two were undoubtedly severe progressive outbreaks of at least two years' standing. One of these, in an old garden of the variety Brewer's Favourite, was near Maidstone and some five miles from the nearest severe progressive outbreak. Four mild outbreaks were reported from the West Midlands during the course of hop garden inspections. Wilt incidence in fluctuating outbreaks was less than in 1946, possibly due to the hot dry summer of 1947, but little effect was noted on the severity of established progressive outbreaks.

(*b*) *Resistance Trials*.—Two new resistant varieties were selected from the thirty Wye Seedlings tested during 1947. The commercial test plots of the older selections were again recorded for wilt incidence. The varieties OB53, OM26, OR55, OJ47, 1147 and 219 maintained a fair degree of resistance on all sites, in many cases recovering from the effects of the disease in earlier years. Large scale commercial plots of these varieties have now been laid down on wilt-infected ground. Of the varieties selected to date OR55 and OJ47 appear the best from a cultural point of view. The varieties

OB53 and OM26 are the most resistant but crop only at the rate of 14 cwt. per acre at East Malling. There are indications, however, that they may produce a bigger crop on heavy land and one equivalent to 17 cwt. per acre has been recorded on some plots. The work on wilt resistance up to 1946 and notes on the selected varieties have been published (C223 and C222).

In addition to the selection of existing varieties for wilt resistance some breeding was done using the older selected varieties as parents. The progeny is being tested for resistance in single plant trials. Several promising male and female seedlings have already been selected by this method and are being propagated for further testing.

(*c*) *Studies of the Pathogen.*—A considerable part of the research was devoted to studies on the strains of Verticillium isolated from various outbreaks. Preliminary results indicate that it may be possible to distinguish between virulent and mild strains of Verticillium by laboratory methods. The results obtained by these methods are being correlated with those from soil inoculation experiments and an attempt is being made to study the distribution of the various strains with special emphasis on the milder type of progressive outbreak.

(*d*) *Wilt incidence in relation to the nutrition of the plant.*—The collaborative experiment at the Long Ashton Research Station on the inoculation of hops growing in sand culture at various nutrient levels was completed and an account is being prepared for publication. A striking correlation between wilt incidence and intensity and nitrogen levels was observed.

Collaboration with Wye College has been maintained on the study of nutrient effects in the field (see also II.). Again, clear correlations between wilt intensity and nitrogen manuring were noted.

Virus and Suspected Virus Diseases.

(*a*) *Nettlehead.*—Symptom records were again made in commercial gardens. Considerable symptom masking was shown throughout the whole season—presumably due to the hot dry weather—and this has rendered field observation difficult. An experiment to determine whether symptom intensity or the spread of the disease is influenced by nitrogen and potash manuring has been laid down in a commercial garden, and a site cleared in a badly affected garden to test the effect of replanting the area with disease-free stock.

(*b*) *Mosaic.*—A number of isolated instances of mosaic symptoms on tolerant plants have been seen. An account of the study of tolerant and sensitive varieties has been published (C227).

(*c*) *Split Leaf Blotch.*—Experiments have shown this disease to be graft transmissible.

(*d*) *Other disorders.*—Two disorders of unknown cause were noted on hops in many districts. One, " Leaf Curl ", caused the leaves to curl downward and become dark green with necrotic flecks. The other is characterized by the presence of irregular " Oak Leaf " chlorotic patterns on the leaves. Cuttings are being collected from typical plants for further study.

Phytophthora Root Rot.

Several severe outbreaks of this disease were noted during early September in the variety Mathon in Worcestershire. In one garden some 5 per cent. of the plants bore several wilted bines and in one portion of about an acre, at least 10 per cent. of the plants were attacked. In many cases the whole rootstock was rotted and dead. In another garden some 3-5 per cent. of the plants were affected in scattered groups of 2-6 plants. The soil in both gardens was deep and well drained and very dry and there was no possibility of flooding during the previous winter. This is the first record of this disease causing extensive damage in the Mathon variety.

On another farm up to 20 per cent. of the plants were affected in plots of certain Wye Seedling varieties, notably AEE44 and Q43 (Bullion).

Propagation of Wilt Resistant Varieties.

A special project was started during 1947 to study improved methods of propagation by layering, using the wilt resistant varieties OR55 and OJ47. The bines from both bedded sets and cuttings were layered by a new technique facilitating the handling of large numbers of plants and the effects of spacing and layer length were studied. It has been found possible to multiply the stock very considerably in one season and the methods appear very promising. The older methods of layering have also been studied.

Publications during the Year.

Thirtieth Report on the Trial of New Varieties of Hops. E. S. Salmon. 1946 (1947). (B59.)

1. Of the 119 New Varieties tested, one (" Bullion Hop " (Q43)) cropped at the rate of 30 cwt. to the acre, four at from 25 cwt. to 28¼ cwt., and twenty-two at from 20 cwt. to 24¼ cwt.

2. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 52 to 155, a larger difference than has previously been met with.

3. It is pointed out that with those varieties where the number of green bushels to the cwt. is relatively low, the cost will be appreciably reduced as regards picking and to some extent in drying and pocketing.

4. English hops generally in the season of 1946 gave a low P.V., but high analyses were obtained for a number of the New Varieties, an outstanding example being " Northern Brewer ".

5. OM26, a bud-sport of " Nonsuch Hop " (OB53), was richer than its parent in soft resins by 1·27 per cent. α-acid and 0·93 per cent. β-resins.

6. Particulars are given of the Competitions for the two Challenge Cups offered for the best growths in 1946 of a New (Wye) Variety of Hop.

7. It is pointed out that fifty-two firms of brewers have undertaken to purchase annually some 6,000 cwt. of certain of the New Varieties. In 1946, 1,868 pockets, or approximately 2,800 cwt., of the New Varieties were distributed by the Hops Marketing Board. It is evident, therefore, that the acreage of the New Varieties requires to be considerably increased in order to meet the brewers' requirements. It is urged that an Experimental Station in the Weald should be established where the approved New Varieties could be tried out on " Fuggle " soil, as it is believed that only by an extension of the acreage on this type of soil will the increase be obtained.

8. Recent experience has shown that many of the New Varieties can be picked by machine with a higher efficiency than the ordinary commercial varieties. Notes are given on the botanical or structural characteristics of the New Varieties which render them suitable for machine-picking.

Propagation Trials With Hops. IV. Further Trials in Propagation by Softwood Cuttings. F. H. Beard and Dorothy J. Wilson. Rep. E. Malling Res. Sta. for 1946 (1947), 131-5. (B60.)

Propagation Trials With Hops. V. Further Experiments in Treating Cuttings (Strap-cuts) With Growth Substances. F. H. Beard and Dorothy J. Wilson. Rep. E. Malling Res. Sta. for 1946 (1947), 136-9. (B61.)

Propagation Trials With Hops. VI. The Effect of Spacing Cuttings (Strap-cuts) in the Nursery rows on the Number and Size of Sets Produced. F. H. Beard. Rep. E. Malling Res. Sta. for 1946 (1947), 140-1. (B62.)

(See also : V, C.222, C.223 and C.227.)

IX. TECHNICAL SECTION

By H. B. S. MONTGOMERY.

The year 1947 has seen the establishment of the N.A.A.S. and a reorganization of the advisory facilities of the Local Education Authorities. It was hardly to be hoped that these services could immediately lighten the load of advisory work now carried by the Station and in fact it was not until the latter part of the year that we could begin to pass much of the work over. The Section received about 4,000 letters, of which 2,080 dealt with advisory matters, and replied direct to most of these, often sending the original enquiry and copy of reply to the appropriate advisory officer. In some cases the enquiry was passed on to the local adviser to deal with direct. This course of action was especially helped by the Kent Education Committee, who stationed one of their horticultural staff at the Research Station, with the result that she directly relieved our staff of some 180 letters. Unfortunately the similar arrangement with the N.A.A.S. was delayed, as the Fruit Specialist concerned could not be installed at the Station until towards the end of the year, owing to difficulties over telephone and secretarial help. Enquiries by telephone continue to be numerous and this must be expected until growers get to know the official advisers.

It has again been a busy year with over 3,600 visitors. Of this number 52 parties from this country account for 1,771, and 10 parties from overseas for 229 ; the attendance at our four Members' Days, a Governing Members' Day and the Hop Open Day came to about 600 ; parties of N.A.A.S. and L.E.A. officers came to 197 ; and individual visitors to 941, of whom 225 were from overseas. In addition the K.E.C. officer, Miss Leslie Martin, took a total of about 500 amateurs from Kent round the Research Station.

The Section has maintained close contact with the N.A.A.S. Fruit Group and collaborated in the preparation of advisory bulletins and leaflets. The Strawberry Bulletin (No. 95) appeared during the year and several editions have already sold out. The bulletin on Plums and Cherries is with the publishers and is expected to appear shortly.

Eight popular articles were written by the Section, but owing to delays in printing only four were published during the year. In addition assistance was given to the research staff, who wrote a further nineteen growers' bulletins. Help was given to the B.B.C. in preparing scripts for broadcasts, especially on the overseas services. Three lectures, one at St. Albans, one in Dublin and one at Tonbridge were given by members of the Section.

Our three fruitgrowing films continued to be in demand during the winter months, and we have assisted the advisory staffs with photographs, slides and other material for lectures. We collaborated with the Ministry of Agriculture in the preparation of a film strip on raising Special Stock strawberry runners and this film strip is now in use in the counties. Educational exhibits were staged at the Chelsea Show, South Wales, Blackpool, Tunbridge Wells, the Royal Horticultural Society and the Association of Applied Biologists in London, and assistance given to county officers for exhibits in various parts of the country. Collaboration with the K.E.C. in providing facilities for fruitgrowing classes for school teachers has been maintained and developed.

Publications during the Year.

Apple and Pear Tree Training for the Garden. A. C. Painter. R.H.S. Fruit Year Book, 1947, 36-42. (E252).

Recommendations are made as to rootstocks and methods of pruning considered most suitable for apple and pear cordons, dwarf pyramids and bush trees when grown in a garden.

Reducing the Pre-Harvest Drop in Fruit. A. C. Painter. Farming, 1, 1947, 242-4. (F45.)

A popular account of how growth promoting substances can be used to control the pre-harvest drop of fruit. The kind of growth substance most suitable for the purpose, the time and method of its application, varietal response and the effect of growth substances on fruit quality are discussed.

Problems of Soft Fruit for the Garden. H. B. S. Montgomery. R.H.S. Fruit Year Book, 1947, 77-81. (T1.)

A practical survey of the troubles affecting soft fruit and what can be done to control them in a private garden.

Failure of Apple and Pear Trees to Crop. A. C. Painter. Rep E. Malling Res. Sta. for 1946 (1947), 154-6. (T2.)

A.R.C. SCOTTISH RASPBERRY INVESTIGATION

By R. V. HARRIS and C. H. CADMAN.

A.—Plant Pathology. (See also V.)

Virus Diseases.

Attention was drawn in last year's Report to the apparent complexity of the virus disease situation in raspberries and to the identification of *Amphorophora rubi* Kalt. and *Aphis idaei* V. d. G. as aphid vectors of raspberry viruses. This was expected to provide an additional technique for resolving the virus complexes responsible for degeneration of tolerant varieties. Experiments in 1947, however, designed to explore this latter possibility have but shown the need for more exact information on the process of transmission itself.

The experiments of 1945 and 1946, a brief summary of which was published, involved the transfer of large numbers of aphids from diseased to healthy plants. The current year's experiments aiming at the resolution of certain virus complexes by means of timed infection feeds and serial transfers of relatively small numbers of aphids, were carried out under conditions thought to be optimum for transmission. The number of successful transmissions, however, is, so far, small and little more than confirmation of previous results has been achieved. It is, therefore, concluded that there are factors at present imperfectly understood which limit the ability of individual aphids to pick up and transmit virus.

Nevertheless, some progress has been made towards an analysis of the virological causes of raspberry decline, largely from the results of last year's grafting to differential Indicator varieties. At least ten distinct viruses, or virus groups, recognizable by the symptoms they produce on indicator hosts, have been identified on raspberries in Scotland and information is now available on the reactions of a range of commercial varieties to these. Except in the variety Norfolk Giant, complex virus infections are most general under field conditions, and the problem is now to discover which combinations are mainly responsible for the degeneration of the " tolerant " varieties such as Lloyd George and Malling Promise.

Work along these lines has necessitated first finding stocks either free from virus infection or of known virus content and the results so far have been encouraging. Particular attention has been given to the Lloyd George variety on account of its commercial importance and the great complexity of its virus reactions, and diagnoses of virus combinations producing visible mosaic symptoms can now be made with some accuracy. There is also evidence indicating that a combination of two viruses of the Mosaic 2 group play a major part in producing " symptomless degeneration ".

Investigation of samples of wild raspberries collected both from areas adjacent to and remote from commercial plantations has shown that they can act as reservoirs of virus diseases commonly found in commercial stocks. This fact will clearly be of importance in relation to propagation schemes and certification regulations.

Additional data on the etiology of the Leaf Curl disease of Norfolk Giant have been obtained, but attempts this season to transmit Leaf Curl by means of the aphid species *A. rubi* and *A. idaei* have, to date, given negative results. There is now evidence suggesting that this disease may be caused by a complex of two viruses.

Following the recent outbreaks of Loganberry Dwarf on raspberries in the south a close watch is being kept on English stocks recently planted in Scotland.

Some attention has also been given to severe forms of cane branching due to pathological causes. There is, so far, little indication that a virus is involved. (See B and C.)

Stock testing work.—Samples from each of the parent stools of the New Zealand stock of Lloyd George, at present being propagated on Loch Tay-side and in the Suffolk fens, have been tested again and the entire stock still appears to be virus-free. The bulk of the cane to be harvested this year is being used to initiate a large scale propagation scheme in co-operation with commercial growers (see C).

Of the 100 new seedlings under trial in Scotland, only three have so far proved to be seriously virus-infected. Until final selections can be made, duplicates of the plants under trial are being kept in reserve for propagation purposes. The adoption of this procedure emphasizes the point that whatever policy is eventually adopted for the propagation of virus-free stocks on a commercial scale, it is important that a reserve of one or two virus-free plants per variety shall always be maintained under adequate protection from infection. The housing of such material is rapidly becoming a problem.

Fungus Diseases.

Spraying experiments on the control of Cane Spot and Spur Blight were continued under seasonal conditions exceptionally favourable to these diseases. Whereas a high degree of control was maintained on the Cane Spot trial run in co-operation with Messrs. Chivers near Montrose, barely a 10 per cent. control was obtained on a new trial with Norfolk Giant and Malling Landmark started at Kirriemuir.

For the second season in succession negative results were obtained on the Spur Blight trial on the farm of Mr. G. M. Hodge at Blairgowrie in spite of a modification of the schedule employed.

B.—Entomology.

Material has been collected this season for the study of detailed host/insect-vector relations referred to above.

Good progress has been made with the biology of the Raspberry Moth (*Lampronia rubiella*) and data on all stages of its life cycle under Scottish conditions are now available. Two salient points emerging from this work are the difficulty of locating the hibernating larvae in the soil during winter and the extended period of larval emergence during spring.

Contrary to expectation, the larvae appear to spend the winter close to the bases of raspberry stools. It was only with extreme difficulty that larvae were eventually found in the soil washed from old roots, and therefore soil sampling does not appear to be a promising method of estimating the size of the overwintering population.

In spring the larval emergence period extends over three weeks, the majority emerging over a ten day period. From the point of view of damage to field crops it is significant that individual larvae frequently leave the first bud attacked and migrate to others on the same cane.

Owing to technical difficulties the complete trial of spraying and dusting measures for control could not be made as planned. Dusting trials using 10 per cent. and 5 per cent. DDT and 5 per cent. Gammexane at two centres in Strathmore yielded positive results ; DDT (10 per cent. dust) especially giving a good control.

Widespread and severe infestations of the clay-coloured Weevil (*Otiorrhyncus singularis*) in many parts of the eastern area provided useful opportunities for insecticide trials. That the weevils are killed by DDT indicates that this insect may be brought more readily under control than hitherto, and applications of 10 per cent. and 5 per cent. DDT dusts on a field scale gave promising results. Weevils appeared in May on one of the areas used earlier in the season for the trial of measures for control of *Lampronia rubiella* and it is significant that weevil damage was much less severe on plots treated with 10 per cent. DDT in March.

Some attention has also been given to severe forms of cane branching thought to be associated with damage to the growing points by Capsids. Preliminary experiments have been carried out in which (*a*) nymphs and (*b*) adults of *Lygus pabulinus* were caged with raspberry plants and in each case the presence of these insects caused branching. Control plants with which no capsids were caged remained unbranched.

An attempt to control cane branching in plantations of Norfolk Giant and Malling Landmark by spraying with nicotine had little effect either on the *Lygus* population or on the suppression of branching.

Survey work on the insect fauna associated with cultivated and wild *Rubus* species and trap records of aphid migration have been continued this season. Noteworthy among the extensive records collected is the absence so far of the Raspberry Cane Midge *Thomasiniana theobaldi* from Scotland.

C.—Pomology.

1. Isolated Cane-Nursery Scheme.

The harvest of canes from the two local (Carse of Gowrie) plots was satisfactory and we disposed of 23,000 canes of Amos Lloyd George and 20,000 certified Norfolk Giant canes at a net profit of £265. The Norfolk Giant canes were sold mainly under the auspices of a scheme designed to further the propagation of nuclear, virus-free stocks in isolation.

Great difficulty was experienced in harvesting the cane from the two highland sites at Aberfeldy and Pitlochry in West Perthshire, the entire crop from the latter being lost as a result of inaccessibility.

The Carse of Gowrie plots, now in their third year, have been utilized for experiments on the cultural management of cane nurseries and the yields of canes harvested are to be recorded at lifting time.

The Loch Tay-side plot, now in its second year, should produce some 6,000 Norfolk Giant canes this year, in addition to the 2,000 canes we hope to harvest from the New Zealand Lloyd George stock also located there. As mentioned above (A) the bulk of the Lloyd George cane is to be used to initiate a five year large scale propagation scheme designed to ensure a continuous flow to the industry of healthy stock raised from pedigree, tested sources.

2. Nuclear Stock Propagation Scheme.

In a project to prevent the loss, by virus infection, of stocks of known or potentially useful raspberry varieties we were fortunate in gaining the co-operation of two growers in Kincardineshire and one in Aberdeenshire who have provided land for the establishment of small cane nurseries of the varieties St. Walfried, Malling Promise, Landmark and Enterprise, and Malling Seedlings J, M and N. The best obtainable stocks were obtained for the purpose and the plots have been rigorously rogued during the season. From each variety 25 selected stools have been indexed for virus content and the virus-free plants so found will be removed and utilized for building up virus-free stocks. The remaining material, with further thorough rogueing, should serve as " interim " stocks to satisfy any demand emerging in the next two or three seasons.

This programme of testing and propagation work will be extended in the near future to such of the newer seedlings as survive their initial period of trial.

3. Field Trials of Raspberry Varieties.

Through the kindness of Messrs. Morrison Bros. a trial, extending over two acres, of the best available stocks of ten current commercial varieties was planted in April, 1947, on one of their farms at Forfar, Angus. The site is a north-facing slope, free from frost and typical of raspberry land in this district. Plant establishment has been good and the growth of young canes very satisfactory.

A subsidiary trial has been established at Aberuthven, Perthshire, through the co-operation of the Hall Farming Co. whose farm manager, Mr. R. O' Neil, has kindly undertaken to supervise the detailed recording work. In topography the district differs considerably from the Forfar area and should provide an interesting comparison of varietal response. The list of varieties included is approximately the same as for the Forfar trial. Plant establishment and cane growth have been good.

4. Preliminary Selection Trials of Recent Seedlings.

As some time will inevitably elapse before new seedling varieties bred specifically for Scottish conditions are available it seemed advisable to bring up to Scotland for preliminary trial a collection of the more recent and promising seedlings raised by Mr. Grubb at East Malling. Canes were available of some 100 seedlings, some in an advanced stage of selection, but the majority selected by Dr. Wood from seedling progenies fruiting for the first time in 1946. This material has been divided into three batches and trial plots established on sites in Angus, Fife and Lanarkshire through the hospitality of local growers.

In co-operation with the pathology programme, samples from new varieties on trial have been indexed for virus content and provision is being made for preserving virus-free stocks until such time as propagation is recommended.

5. Cane Branching Trial. (See also B.)

The results of a small replicated trial planted at West Park with (*a*) unbranched and (*b*) severely branched canes of Norfolk Giant, Malling Promise and Malling Landmark gave no indication that branching is a persistent condition ; incidence of branching in the (*a*) and (*b*) sections was approximately equal.

The problem of branching and premature failure of growth of canes is obviously a complex one. There are many different types of branching and an equal variety of causes. Whilst direct insect damage is a recognizable cause of the condition, it seems more probable that the chronic forms are to be traced to nutritional causes rather than to a specific virus infection.

6. Rapid Methods of Raspberry Propagation.

An investigation of the possible use of root cuttings as a method of rapid propagation of raspberry stocks was begun. Batches of cuttings were bedded at intervals through January and February (in electrically heated frames) and April (in boxes in a well-lit greenhouse). The rooting response was, on the whole, disappointing, though more rooted cuttings were obtained under open-greenhouse conditions.

Trials of growth promoting substances including β-indolyl-butyric and α-naphthalene-acetic acids indicated that these had an injurious rather than a stimulating effect on root growth.

Publications during the Year.

Aphid Vectors of European Raspberry Viruses. C. H. Cadman and A. R. Hill. Nature, 1947, **160**, 837. (C230.)

From experiments started in 1944 it is concluded that two aphid species occurring generally on raspberries in Scotland, *Amphorophora rubi* Kalt and *Aphis idaei* V. d.G, are capable of acting as vectors of certain viruses commonly present in Lloyd George and other stocks, under Scottish conditions.

Section III

RESEARCH REPORTS AND REVIEWS

GENERAL

AMOS MEMORIAL LECTURE*

FRUIT RESEARCH—SOME THOUGHTS, PAST AND FUTURE

By CAPTAIN R. WELLINGTON, M.C.

The Amos Memorial Committee, of which I am a member, found themselves very restricted in their choice of a suitable manner of utilizing the funds at their disposal to preserve Jesse Amos's memory and his outstanding contribution to the initial success of the Station. The interest from the investment of even a large sum of money at the present time yields so little that the institution of an Annual Memorial Lecture seemed the only possible suitable choice. So it was decided that this lecture should be given annually on some aspect of pomology or fruit research by a recognized authority in a particular field.

I think I hardly come within these terms of reference, and I was very loath to accept the invitation to give this address for many reasons. However, maybe the Committee were right to ask me to give this first lecture for I think it should be of an introductory nature to the series. Seeing that I have been associated with the Station almost since the inception of the idea, at its actual commencement and later in a detached capacity, partly as a member of the Governing Body but also as a fruitgrower in a distant part of the country, and as the spectator is said to see most of the game, I am therefore competent to review the progress of fruit research work in general and of the work and achievements of the Station in particular.

I propose, therefore, to deal in this lecture first with the past history of fruit research from the time prior to the inception of the idea that a research station should be started in Kent up to the present time, with the original research programme and policy decided upon, with how this has been carried out and the results achieved, and secondly to give some personal views of my own on problems which I think have been overlooked but still require elucidation.

And in doing this I can place on record what I know of Jesse Amos, of his character and knowledge and of the contribution he made to the successes that the Station has achieved so that his outstanding qualities may not be forgotten, but may be a pattern to all workers connected with the Station and at the same time that those engaged in the practice of fruitgrowing may realize the debt of gratitude they owe to him, one of an outstanding team of workers.

I want to commence my story about 1907, forty years ago. At this time fruitgrowing was largely confined to Kent and Worcestershire. It was a profitable business and the knowledge of it was largely a family affair possessed only by the growers concerned and passed on from father to son.

The demand for fruit was rapidly growing and an extension to other areas was commencing – to Wisbech, Cambridgeshire, Essex and elsewhere. In Kent, hop growing was in the doldrums through low prices and many hop growers, looking for an alternative crop, commenced replacing their hops with fruit. The younger generation of growers then coming on were keenly alive to the prospects offered in commercial fruitgrowing.

At this time commercial fruit culture was based on the accumulated practice of long years of growers' experiences gained by methods of trial and error in the field, and by very acute observation. There was practically no technical fruitgrowing knowledge available and because of this the extension of the industry in new areas was fraught with much risk and resulted in many failures that could have been avoided. Abroad large areas of top fruits had been planted in British Columbia and in the United States, in Oregon and Washington ; these were then commencing to produce large quantities of first quality produce, much of which was exported to this country.

In this year I went to Wye as a student. A. D. Hall had recently left to become Director of the Rothamsted Experimental Station, and Dunstan had succeeded him as Principal. There were then

* The text of the first Amos Memorial Lecture given in the Great Hall, Bradbourne, on Thursday, 11th March, 1948, with Mr. N. B. Bagenal in the Chair.

many outstanding personalities either on the staff of the College or recently left ; Russell was chief chemist, shortly to leave for Rothamsted, Theobald was head of the Entomological Department and was undoubtedly the leading economic entomologist of the day, having followed Miss Ormerod in this respect, and Salmon was research mycologist and besides being engaged in the control of fungus diseases generally, was engaged in a wordy battle with Massee's father at Kew over the control measures necessary to combat American Gooseberry Mildew, then recently introduced from America. In botany, Percival, Cousins and Howard had all recently left and Parkinson was in charge.

In fact, and I hope I say it without offending anyone, Wye at that time was the leading centre of agricultural thought and knowledge in the East of England, and was producing a marked effect on agricultural practice. This was the commencement of a revolutionary change—the convincing of the practical grower and farmer that technical knowledge could be of great assistance to him and could not only improve his resulting crops but could prevent many crop failures. Needless to say there was still great scepticism amongst farmers generally as to the value to them of technical advice.

In Kent, however, there were many outstanding successful fruitgrowers of very great practical knowledge who were keenly alive to the many baffling problems that prevented them in many cases from achieving the results that seemed almost certain. May I mention a few : Fred Smith of Loddington and his sons, the Champions, Fred Neame of Faversham and his sons, George Mount of Canterbury and his sons, James Edmonds and his sons and the Vinsons, Manwarings, Mays, Bartholomews, Chambers and many others.

The assistance received from Theobald and Salmon soon convinced these men of the value of technical advice, and it became apparent to Dunstan, a man of great vision and enterprise, that it was necessary to extend technical assistance to the fruitgrower to cover not only disease control but the whole field of pomological practice.

To begin with, Fruitgrowers' Conferences were held at Wye. At one of these, which I attended as a student, Mr. Spencer Pickering, the Director of the Woburn Fruit Experimental Station, told his audience, composed of all the best practical fruitgrowers in the country, that their methods of planting fruit trees were quite wrong. He described his trials and supported his conclusions with statistical evidence. I well remember Mr. George Mount almost coming to blows with him for propounding such a view. Pickering was, of course, a very provocative man. The results of his trials were nearly always at variance with the then best-recognized practice, largely because he over-simplified his problems and often drew wrong conclusions owing to the lack of knowledge of the physiology of growth.

These Conferences caused much thought amongst all sections, both growers and scientists, and focussed attention on the very great ignorance of the scientific facts underlying cultural knowledge. They impressed Dunstan with the need for research work to provide sound technical knowledge on which to base the advice he wished to give.

Dunstan's next step was to inaugurate a course of lectures in practical fruitgrowing at Wye, and Cuthbert Smith was appointed lecturer. All fruitgrowers owe him a deep debt of gratitude for this, for it was the first occasion on which the practice of commercial fruitgrowing was described in detail in all its aspects. Both the present Director and myself attended those lectures and I often wish they had been published. All those who attended them will agree that they formed the foundation for a study of pomological science.

Complementary to Smith's lectures on practice, a start was made to teach horticultural science, or rather science in relation to fruitgrowing. A past student of Wye, W. B. Burgess, one of the first to gain the London University B.Sc. in Agriculture, was selected as lecturer, and at the same time he was instructed by Dunstan to draw up a list of problems on cultural methods requiring research. Dunstan then had in mind the inauguration of a Fruit Research Station in Kent to be closely related to Wye and the teaching arrangements there. Burgess was a man of outstanding qualities and the industry lost a brilliant worker by his untimely death.

I finished my student days at Wye in 1910 and was then undecided what I should do. I was contemplating going to the States to study fruitgrowing there, but prior to this went to gain further practical experience at the Toddington Orchard Company in Gloucestershire. I was there in Spring, 1911, when at Whitsun, Burgess met with an accident which completely paralysed him and from which he died a few months later. Dunstan wired to me to return to Wye immediately to take Burgess's place.

This was a great undertaking for me, with no very high scientific qualifications, and yet an opportunity. There were no textbooks or collated material on which to base a course of lectures on the sciences generally with special application to fruitgrowing. How little was known was soon brought home to me. It seemed almost an effrontery to give such a course of lectures. The only real source of knowledge for this purpose was the many articles which had appeared from time to time in the horticultural papers, mainly the *Gardeners' Chronicle* (fortunately the library at Wye had the complete

set of this from when it was first published), the *Fruit-Grower* and the American publication *Better Fruit*, and also in the Journals of the Royal Horticultural Society, Royal Agricultural Society and various others from the colonies.

Let me here give a short résumé of the state of fruitgrowing at this time :

(*a*) The value of rootstocks was almost unknown except that certain "paradise" stocks of apples were known to induce dwarfing and that the free stocks, seedlings, gave large trees. Similarly quince stocks were known to be dwarfing for pears. Little was known of stocks for plums and cherries. Not only was little known of the value of stocks but, as was found at this Station later, the varieties were hopelessly mixed.

(*b*) Bramley's Seedling was then never subject to apple scab or canker, although Cox's Orange and Worcester were very badly attacked by both. Cox's Orange was so badly attacked that it was generally considered useless as a commercial variety.

(*c*) Virus diseases generally, including those of soft fruits, were quite unknown.

(*d*) Black currants were a very chancy crop, because Big Bud was quite uncontrollable. The cause of Reversion was unknown. The value of the crop was normally around £100 per ton.

(*e*) American Gooseberry Mildew was extending so rapidly, and the attacks were so severe, that it looked as though gooseberry growing would become impossible.

(*f*) Tar Oil Washes were unknown. The only way of obtaining some control of aphides and apple sucker was by preventing the eggs from hatching by coating the trees with lime wash just before bud break. The killing of eggs actually laid on the tree was thought impractical. Theobald maintained that the egg coats being made of chitin were so resistant, that any substance that would kill the eggs would certainly kill the tree. Actually, about 1912 I visited Holland and was told of the amazing results obtained from the use of tar oil, but when I told Theobald about them on my return he pooh-poohed the idea and it was not until after 1918 that tar oil was introduced to this country.

(*g*) Nothing was known of fruit bud differentiation—either how or when it took place.

(*h*) There were no tractors or power sprayers.

(*i*) There was no storage of fruit in cold or gas stores.

(*j*) Fruit pulping was unknown.

At the time when I returned to Wye, Dunstan had already made up his mind that a Fruit Research Station should be started in Kent, and in this he was ably supported by the late Lord Cornwallis (then Mr. Cornwallis), and many growers. One of the main criticisms made by growers about the Woburn Fruit Station and Long Ashton, was that they were situated outside the normal fruitgrowing areas, which were then thought to be quite circumscribed, and results obtained at these Stations were consequently thought of little value.

Much negotiation was carried on with the Board of Agriculture and the Development Commission (which at that time carried out the functions for which the Agricultural Research Council is now responsible) before the proposal was authorized—more particularly because the Board were then committed, mainly for political reasons, to making Long Ashton the chief, if not the only, Fruit Research Station in the country.

A very small sum was all that was authorized for maintenance ; £500 annually, provided a similar sum was forthcoming from local sources. Later as it was found impossible to provide this the Board agreed to give their grant provided a capital sum of £3,000 for the purchase and equipment of the land was found from outside sources. Thanks to a guarantee by Mr. Cornwallis this project soon took shape once this decision was obtained, though it took some years to raise the money and dispense with Mr. Cornwallis's guarantee. Compare this with the annual grants now made to the Station of £50,000 and with the capital sum invested in land and buildings, which must be at least £100,000. How this came about is another story, but I feel sure that few, if any, could have emulated the efforts of Dr. Hatton in this respect.

After considerable search and much outside advice by local growers, the original piece of land on Ditton Court was acquired, and I was appointed Director, the only tangible equipment being 22 acres of land at Great East, with no fences, road access, or buildings and very little money, but plenty of hopes and ideas. Within a year the first range of buildings was erected. I myself, in order to save money, designed them, prepared the quantities and acted as Clerk of the Works.

We had grandiose schemes for staffing for the future, a physiologist, chemist, mycologist and entomologist, but funds would only permit of one worker besides myself. For this post I wanted someone who was methodical, had very good powers of observation, had a knowledge of systematic Botany, of laboratory work, including histological technique, and was a grower and so could take charge of labour. It would be difficult to find anyone with these all-round qualities even nowadays, with all our extensive opportunities for technical training.

Whilst I had been a student at Wye, Amos was laboratory assistant in the Botany Laboratory. He was everyone's friend and counsellor, his knowledge of systematic Botany was immense and he was

a good grower. To us students, he taught quite as much Botany as did anyone else. The son, I believe, of a farm labourer, he went to the local Board School and presumably left at 14, going straight into the Botany Laboratory. This is what Professor Salmon has to say about Jesse Amos in a recent letter to Dr. Hatton :—

> " Perhaps you would like my earliest recollection of Jesse Amos, in days now so long ago. He came as a village boy to help the Botany Department at Wye College ; although I had nothing to do with him I soon learned from the Botany lecturers, particularly Parkinson, how quickly he learnt to recognize the species of wild flowers and grasses, and to know where to collect them in bulk for the classes. He had that intuitive faculty of recognizing the distinctive " habit " of a plant, and I remember well thinking ' that boy is an illustration of the truth that systematic botanists are born not made '. It was indeed fortunate that he could move on to E.M.R.S. to find there just the right conditions for the development of his talents."

It seemed to me at the time that Amos had every attribute that was required for the post at the Research Station. The question was, could he be attracted away from the Botanical Department, or were his roots so firmly set at Wye that he could not be transplanted successfully. Amos came to East Malling with some misgiving. He had a most miserable time for the first few years, but his stolid character saw him through. His systematic botany training, his very acute powers of observation, his skill as a grower, his immense knowledge of everything at the Station, his sound advice, his steadfastness of character and his curious sense of humour made him a pillar of strength to the Director, and the counsellor, adviser and friend of whoever came to the Station, whoever they were, grower or research worker. I had the very highest regard for him and I think the greatest tribute I can pay him is to say that I knew of no fault whatever, of any consequence, that he possessed.

At this stage came the first World War, and I left to serve in the Forces, but already a collection of apple rootstocks had been made from all the sources possible not only in this country but also from abroad. These Amos looked after carefully besides managing the remaining land at the Station under Hatton who eventually took over the Directorship in 1918. Thereafter he and Hatton worked together. The results of this association, supplemented as time progressed by the other outstanding appointments to the staff, are fully recorded in detail in the *Annual Reports*, and there is no need for me to say much on this score.

I have already given, at some length, a résumé of the condition of fruitgrowing when the Station was inaugurated. Is it not amazing that in such a comparatively short period so much knowledge of practical value to the industry should have been acquired ?

The list of achievements in Fruit Research during the period under review and in no small degree emanating from East Malling, either alone or in association with other institutes, is a massive one. Let me, lest we overlook them, enumerate the chief of them, and as probably I shall never have the opportunity to do so again, may I say that this whole edifice is really the personal contribution of the Director with the help of a very diverse, but none the less loyal and efficient, team ; whether they be members of the Governing Body, the Ministry, or of the research staff of the Station itself.

1. **Rootstocks.** Systematic selection and description for all top fruits, with the testing of their relative value and particular use.

2. **Soft Fruits.** Discovery of virus diseases affecting them, description of virus symptoms, separation of one virus from another, transference from plant to plant, leading ultimately to the practical elimination of virus and the propagation of virus-free stock.

3. **Estimation of Soil Values** and of **Mineral Element Deficiencies** in fruit trees by spectrographical means.

4. **Manuring** of Fruit Trees with special regard to NPK.

5. **Pest and Disease Control.**

Entomological. Control of aphides and caterpillars, black currant big bud mite, strawberry tarsonemid mite, apple sawfly, apple blossom weevil, leatherjackets, wireworm and slugs.

Mycological. Control of scab, canker and American gooseberry mildew.

I want now to say a few remarks to the present staff of the Research Station. One of the most valuable attributes that Amos possessed, next to his powers of critical observation, was that he was a grower, and had a grower's tradition. This is a most necessary attribute of anyone engaged in pomological study or for that matter of anyone engaged in agricultural or horticultural research, for if this is not possessed an appreciation of the finer points of cultivation and growing technique is impossible, and a decision on what is practical or impractical to apply cannot be made. I think it would be much better for the ultimate work if all post-graduate students who intend to do such research spend at least one, and better still two years, on a course of practical growing of some kind.

This growers' tradition in the staff of East Malling generally has been of outstanding value. The cultural technique at the Station has always been impeccable and as a result visitors are immediately impressed. If the cultural side of an institution is above reproach, research results are taken much more at their face value by the practical grower and are not regarded with suspicion. I want to emphasize this point for I have seen so much good technical work ruined in its application and final completion by lack of this knowledge by the worker.

So much for the past, and of the achievements to date. What of the future ? I want to offer some suggestions. The original policy of research at the Station was separated under two heads :—

1. **Fundamental Problems.** In the case of fruit these are embraced in the study of the growth and fruiting of trees, and their maintenance in health by purely cultural means.

2. **Ancillary Problems of Immediate Practical Importance**, whether related to cultural problems or to the control or eradication of disease.

All agricultural and horticultural problems can probably be divided in this way but as research stations grow larger they tend to become departmentalized and there is great difficulty in welding the whole into a homogeneous entity, giving each part its correct emphasis. When this happens the study of the main fundamental problems is inclined to be lost sight of or neglected and the ancillary problems receive undue emphasis. I rather feel East Malling has reached this stage now.

At present our technical knowledge has increased to such an extent that we have the knowledge, if we care to and can apply it, of obtaining a very large measure of control over many of the factors governing fruit production. In fact the practical grower, if only he were able to carry out all the operations science has told him are necessary or available for use if required, and could time them correctly, could produce satisfactory crops, given normal climatic conditions. But the time is fast approaching when, so far as the practical grower is concerned, although he knows that certain operations should be carried out, with correct timing as the key to success, he is unable to do so because either he has insufficient labour or the cost of the operations is not warranted by the returns likely to accrue from them. This is certainly true in the purely agricultural sphere and may soon become so in horticulture. In fact, in many respects, our research knowledge is now in advance of what many growers are able to apply practically.

To my mind the aim of research in future should be reoriented to eliminate control operations as far as possible and to achieve the same ends by normal cultural means. To quote an extreme example, is the right way to maintain a crop of Cox's Orange, to spray the trees with a substance to fix the developing fruitlets on the tree so that they may reach maturity rather than to cultivate the tree so that it produces the same result of its own volition ?

There are two major problems, the study of which in my opinion should be intensified. They are basic problems, which have been before the Station since its inception, but little work has been done on them and our knowledge is still very limited.

First, the causes affecting and the conditions influencing the differentiation of fruit buds from growth buds, and their ultimate flowering and the production of fruit.

Second, the optimum cultural conditions required to maintain the tree in health, growth and fruiting balance. And having reached some conclusions on these, how deficiencies from these conditions can be ascertained rapidly and made good.

1. Differentiation of the Fruit Bud.

So far as I know, all we know of this is that in the top fruits differentiation takes place between June and August, but the reason why the differentiated bud produces flowers the following year or remains dormant for a year or more is quite unknown. There are theories that the Nitrogen-Carbohydrate relationship plays an important part and also that the development of a certain hormone or auxin and of a certain quantity of it is necessary. It appears that pruning can influence it. Some or all of these factors may be involved, but there would still remain much to be explained.

There is no doubt that the problem is very complex, although it probably would be generally agreed that fruit bud formation is dependent on certain conditions of (*a*) water supply ; (*b*) mineral element supply ; (*c*) effect of sunlight ; but also, and quite as importantly I feel certain, on (*d*) photoperiodism, that is the effect of length of periods of daylight and darkness ; (*e*) temperature changes, mainly in the direction of retardation, through the effect of a minimum temperature. These last two factors are of course related to the nutritional state of the plant as regards water supply, mineral supplies and general photosynthesis.

Undoubtedly the answer to biennial fruiting will not be obtained by sectionalizing the problem but only by intensive team work from every angle. Furthermore, these same influences may affect the cropping of all fruits and may not necessarily be confined to the top or hard fruits.

2. Optimum Cultural Conditions Required to Maintain the Plant in Perfect Health.

This problem reacts on that of the differentiation of fruit buds and is a correlated problem. It must be the basis of disease control. In this connection a much greater study of the effect of the soil is required ; we lag behind in new knowledge on this. I have had a good deal of experience in recent years over a wide range of soils in varying localities, with vastly differing climatic conditions, and I am bound to say our knowledge of what happens in soils generally is very little, and our means of rapidly assessing the value of a soil are almost negligible. In fact our knowledge of the soil has been added to very little in the last forty years.

Though some of the claims of the late Sir Albert Howard's disciples for composting are quite absurd, there is certainly, in my opinion, a very large amount of truth in the value of humus. But what does it do ? Is the value of it in the soil flora it produces ? Why do we know nothing of the action of the soil bacterial flora ? And what are the relative differences between " live " and " dead " soils, they are not just due, in many cases, to mineral deficiencies ? And why can soil be run out, become tired, in the absence of added organic matter, even though N.P. and K. are added in requisite quantities ? Surely it is not solely the water holding effect of the organic matter.

May not many of the plantations in the various fruit districts, say in Essex where nothing but mineral manures have been applied for years, be actually in a very exhausted state ? And may not this, in perhaps quite devious ways, affect the development of fruit buds and determine the crop yields and whether the fruitlets remain on the tree or are abscissed prematurely ?

In this connection I would like to say that it has always seemed to me a great pity that the general application of the results obtained by the Station on the spectrographical analysis of soils through the plants grown in them has not been continued as a first priority, for in this I could see great possibilities for a rapid assessment of soil values for use not only in fruitgrowing but also in agriculture generally.

Difficult though I know these problems to be, I throw out the suggestion that at the next review of the Programme of Research Work at the Station every effort is made to plan work, from all possible angles, on these fundamental subjects ; to investigate them properly will require team work from every section of the Station.

Finally, it is my earnest hope that the direction of the research programme will remain in the hands of the Director and that the new financial set-up, by which the financing of the Station is wholly in the hands of the Government, will not ultimately lead to official interference with his direction.

POMOLOGY

DESCRIPTIONS OF SOME QUINCE ROOTSTOCKS

By H. M. TYDEMAN

Researches into the quinces in use as rootstocks for pears were started at East Malling in 1914, when some fourteen preliminary collections were got together from various English and foreign nurserymen.

Hatton (1920) reported that these collections showed :

(1) That there was more than one variety in common use.

(2) That the varieties differed considerably :

(*a*) In ease of rooting from layers and cuttings.

(*b*) In actual vigour of growth and health.

(*c*) In early and mature root system.

(*d*) In habit of growth and botanical characters.

(3) That the correct nomenclature was lost ; and that different varieties were sent out under the same name.

(4) That several varieties had got mixed together.

(5) That the variety of quince most recommended as a stock by the older writers—the Portugal quince—had practically gone out of use as a stock.

After sorting out the material, Hatton described five main groups or types which, on account of the difficulties of nomenclature, he called Types A, B, C, D and E. Type A he thought was probably the true Angers quince, both because it had long been known and widely circulated and because the description of its fruit seemed to confirm the consensus of opinion. B, received as " Common " quince, might possibly be the Common English quince of the literature. C, which occurred mixed with A under the label " Angers ", differed markedly from the rest and was almost certainly not the true Angers. D, a very spreading type, was received as " de Fontenay ", but as the stocks received under that name were very mixed and included elements of quite different habit, there was much doubt about what could be regarded as the true Fontenay quince. Type E was without much doubt the Portugal quince, usually grown for its fruit, but widely recommended as a stock by the older pomological writers.

On completion of the classification, the next step was to compare the five recognized types as rootstocks for pears. Trials showed that only three of them, Malling A, B and C, were at all suitable, the other two proving incompatible in varying degrees. Hatton (1928) described the behaviour of pear varieties upon these stocks and illustrated the considerable differences in vigour and earliness of fruiting between trees on A and C and the unsatisfactory behaviour of trees on D and E.

In later years further collections and trials have been made, both with the general object of increasing our knowledge of the quince rootstocks and, more particularly, in the hope of finding types suitable for varieties of pear that are incompatible with the quince rootstocks in common use.

This paper is mainly concerned with botanical descriptions and classification of some of the more recent additions to our quince collections. The following paper, by R. J. Garner (p. 65 of this Report) records the behaviour of a pear variety worked upon a number of them.

Materials and Methods.

It has been known at East Malling for some time that there are varieties of quinces, in use as rootstocks for pears on the Continent, that were not represented in the original collections ; notably the so-called Cognassiers de Provence, grown on certain nurseries in France, and the Quitten von Pillnitz, selected by Professor Schindler and being used in parts of Germany. It has been claimed for the Provence quinces that varieties of pear which do not ordinarily thrive on the quince will do well on them, and for that reason they are of special interest.

Through the kindness of friends on the Continent, several varieties of Provence quince collected from different French nurseries, five types of the Pillnitz quince and one variety under the name " de Fontenay " were received at East Malling in March, 1939. Three varieties of the Angers quince, as grown on one of the best known French fruit tree nurseries, had previously been received in January, 1936. These form the basis of this account.

In general, upwards of twenty individuals of each variety were sent and one specimen of each lot was allowed to grow into a bush without restriction whilst the rest were stooled for studies of nursery

behaviour. The bushes, now almost fully grown, have been observed at all seasons of the year for several years.

As Hatton has pointed out in his earlier paper, the quince is not an easy subject for the systematic pomologist in search of a ready means of discriminating between varieties. The genus shows remarkably narrow variation in most of its characters, but very close superficial similarity is often accompanied by wide differences in behaviour when the varieties are used as rootstocks. Hence it has been found necessary to make much use of measurement to reinforce more general observations, and quantitative data have proved valuable in bringing to light differences not always very readily perceived by other means.

In grouping the material for description and comparison, names have been applied in a wide sense and as a matter of convenience. It is evident that the names current in France have a geographical rather than a strictly botanical basis and that there is no one " true " Angers, Provence or Fontenay quince. Use of these names in a restricted sense would therefore intensify present nomenclatural difficulties, apart from the further confusion that arises from mixture of stocks. Since, however, the material under review falls definitely into groups, some group names are convenient. Types which appear to fall into the same group as Malling A were mostly received as " Angers " and can apparently be referred to collectively as quinces of Angers without serious risk of error or confusion. Similarly the Pillnitz and Provence quinces form definable groups which there is no reason to regard as misnamed. On the other hand, the significance of the name " Fontenay " is still in doubt, as shown in the discussion under that head.

A summary is given of the principal characters of the groups here recognized and Tables I-IX give comparative data both qualitative and quantitative.

1. The Quinces of Angers.

Until 1936 this group was represented in our collection by Malling A, isolated by Hatton from material received in 1914 as Angers. Botanically, Malling B, though isolated from material received as " Common " quince, is undoubtedly closely related. Apart from its slightly less vigorous growth there is very little to distinguish it from Malling A and it is included in the Angers group in this paper.

The three varieties received as Angers in 1936 were described by the senders as (i) " à port érigé " (called C28 in this paper), (ii) " à rameaux buissonnants " (C29 in this paper) and (iii) " à petites feuilles " (C30 in this paper). They were planted out with Malling A, Malling B and Malling C for comparison.

The variety C29 (" à rameaux buissonnants ") very soon gave evidence of being much less vigorous than the others and, by the end of its twelfth year, had scarcely attained a height of four feet and a spread of three feet. In most of its characters it showed a remarkable resemblance to Malling C and will be described with that variety in the second group.

Neither C28 nor C30 was identical with Malling A. Indeed, both differed more from that variety than did the so-called Common quince Malling B. Nevertheless they showed sufficient general resemblance to be included in the same group.

As a class, the Angers quinces may be distinguished by their slender, wiry, rather zigzagged, deep brown, almost glabrous shoots and the vigorous, erect, rather dense bushes. They are all somewhat late in season of leaf break and the dormant shoots have been fairly severely damaged by frost. The foliage leaves are smaller and more circular than those of other varieties and the buds on the dormant shoots shorter, broader and blunter. They have been very shy flowering, at any rate in their earlier years and, although several of the bushes had attained a height of nine or ten feet and a spread of up to twelve feet by the end of their twelfth year, they had borne only a few scattered flowers. The fruits were smaller than those of the Provence varieties and were generally less conical, broader and more oblate in outline. They were fairly early in season of ripening and were usually quite strongly scented.

The twelve-year-old bush of C28 was somewhat larger than that of Malling A and that of C30 was considerably smaller. Both had the dense bushy habit typical of the Angers quinces and there was little evidence that C28 was more erect in habit in spite of the sender's description of it as " à port érigé " (cf. Fig. 1). C30, " à petites feuilles ", on the other hand, actually had smaller leaves than either C28 or Malling A, although they were not so small as those of the very diminutive C29 (see Table VI). On the bush of C30 the buds on the dormant shoots were larger and the lenticels somewhat fewer.

The fruits of C28 and C30 were very similar in size and shape, both being smaller than those of Malling A. They differed in season of ripening, however, those of C28 being much earlier than those of C30.

In spite of these numerous small points of difference, these Angers quinces were by no means easy to distinguish, particularly from the characters of the shoots arising from the stools.

2. The Malling C and Related Quinces.

The occurrence of the very distinct C29 among the material sent as Angers is particularly interesting in view of the fact that Hatton (1920) similarly found Malling C intermixed with the Angers that he studied. It seems likely that Malling C, or a variety like it, is still being circulated under the name of Angers.

Varieties belonging to this group may be readily recognized by the extremely dwarfed, compact and erect growth of the bushes. The young shoots are slender, wiry, short and much zigzagged, the buds in winter are small and globose, of a dull brownish crimson flecked with grey with rather loosely arranged outer scales. The bushes are latish in season of breaking into leaf in the spring and the earliest foliage has a very characteristic bright golden yellow colour which makes the varieties of this group very easy to distinguish at that season. At East Malling, the bushes of these varieties have been less severely damaged by frost than those of the Angers group. The leaves are small, broad and rounded, usually without stipules. Throughout the thirty-four years during which it has been under study here, Malling C has never been known to produce a single flower and this apparent sterility is common to all the botanically similar varieties that have been studied here. It is, however, interesting that Maurer, in his Handbuch, publishes a very brief description of flowers of Malling C and adds the remark " hat noch keine Fruchte gebracht ".

We also received a quince from Holland under the designation " Kwee ", among the original collections, which, although it resembled Malling C very closely in most of its characters, appeared somewhat more vigorous in its growth. When tried out as a rootstock, budded with the pear varieties Dr. Jules Guyot and Reine des Poires, it proved more incompatible than the Angers. Later observations have confirmed its close botanical resemblance to Malling C, although it seems to be rather more susceptible to damage by frost. Like C, it has never borne any flowers at East Malling.

In general, C29 was very similar to Malling C. The foliage leaves seemed, on the average, somewhat smaller and broader and the annual growths rather shorter and more slender. The buds upon the shoots in winter appeared broader and more rounded and the lenticels were fewer and smaller. In comparison with the Angers varieties with which it was sent, it remained extremely diminutive even after twelve years ; the growth was dense and erect and the young foliage was characteristically golden yellow in colour.

3. The Quinces of Pillnitz.

Although apparently little known among the pear tree nurserymen of France, the Quinces of Pillnitz have come into use in certain nurseries in Germany. They were first introduced by Professor O. Schindler, Direktor der Hoherin Staatslehranstalt für Gartenbau, Pillnitz a.d. Elbe, who seems to have selected them from seedlings of the Angers quince on account of their exceptional resistance to frost damage and other good qualities. Schindler has himself described them in some detail while Maurer (1939) in his Handbuch has given a résumé of their botanical characters.

We received the five varieties of these quinces through the courtesy of a firm of German nurserymen in the early spring of 1939. They arrived under the numbers R1, R2, R3, R4 and R5 and, as these are the numbers used by Maurer and Schindler in their discussions and descriptions, they will be retained in this paper. A number of individuals of each variety were received, only one of which was allowed to grow on into a bush, the rest being cut down to form stools.

At the outset it can be said that these rootstocks were by a good deal the most resistant to frost damage of any of those being studied, although they varied somewhat in this respect, R4 being fairly severely damaged during the very severe winter of 1946-47. In their general characters they showed their derivation from the Angers quinces fairly plainly. The bushes were of only moderate size by their ninth year, with the rather dense, bushy habit and slender, somewhat wiry shoots of the Angers. The buds were broader, blunter and more rounded than those of the Provence quinces and they were not so closely pressed against the shoots.

Like the Angers, they were latish in coming into leaf in the spring, but the earliest foliage seemed definitely less yellowish in colour. As a class, they were noticeably shy flowering and up to their ninth year, all, except R4, had only borne a few isolated flowers. These were rather small and inconspicuous with narrow, downturned sepals and were among the last to open. Only R1, R3 and R4 have fruited so far and the fruits were very variable in both size and shape. Mostly they were small and rounded, without the neck at the stalk end so characteristic of most quince fruits. The profuse greyish brown woolly pubescence, conspicuous on the fruits of the Provence varieties, was only present to a limited extent,; the core and seed locules were proportionately larger, the seeds fewer and more rounded.

In the size and shape of the foliage leaves these varieties varied considerably but, in general, they were rather smaller and broader than those of the Provence quinces with less drawn out and acutely pointed tips. They differed from the Angers varieties in being much earlier in losing their leaves in the

autumn and this early dormancy may possibly have something to do with their greater powers of resisting cold.

Among these five varieties the most notable was R4. This was sufficiently distinct from all the others to suggest that it may have had a different ancestry. Indeed, in some respects, it seemed to have more in common with the Provence than with the Angers group. Where the other Pillnitz varieties have produced only an occasional and isolated flower or none at all, R4 has flowered prolifically and the flowers have been larger and bolder with broader petals and sepals (see Table VII.) The fruits, too, were considerably larger and of a more conical shape (see Fig. 14, No. 7). They were remarkable for their deep yellow flesh and strong quince-like odour. This variety was earlier than the others both in season of flowering and in season of leaf break. The young shoots appeared stouter and straighter and of a brighter colour, the leaves were somewhat larger with distinctly serrated stipules.

Among the other four varieties there were numerous small points of difference. R5 was certainly the most vigorous, having made a bush some 8 feet high by 10 feet across by the end of the ninth year (see Fig. 2). It has never produced more than one or two small, inconspicuous flowers, opening late in the season and has not, so far, developed any fruits. The fruits developed by R1 and R3 were quite unlike those of the Angers varieties, being smaller and flatter (cf. Fig. 14, Nos. 5 and 6 with Fig. 15, Nos. 8, 9 and 10). Fruits of R3 had a smaller core than those of R4 with fewer seeds which were smaller and broader.

On the stools these Pillnitz quinces seemed less vigorous than either the Provence or the Angers varieties and could not be distinguished from one another on the characters of the annual vegetative shoots.

4. The Quinces of Provence.

According to our French correspondents, the so-called Cognassiers de Provence grow in a wild state in the hedgerows of the Provence region of France, where they are collected and sold in the local markets as rootstocks for pears. It seems that many of the leading firms of French nurserymen have their own particular selections of this Provence quince which they multiply by vegetative means. As a class, the Provence group of quinces is credited with superior powers of drought and disease resistance and varieties of pears which are incompatible with all other quinces, are said to do well on them.*

In this paper only four of these selections of the Provence quince are dealt with. Each came from a different nursery in France and they are numbered C51, C52, C53 and C54 for convenience of reference. Although they vary considerably they have a strong family resemblance and differ in important respects from the other groups of quinces being studied. All may be readily distinguished from the other types by the profuse whitish pubescence which covers the young wood in the early winter immediately after leaf-fall (see Fig. 6). Unfortunately this is very readily washed off by the winter rains and rarely persists right through the dormant period.

On the stools they make stoutish, robust shoots which are not difficult to distinguish from those of the Angers not only by their stouter and straighter growth and the rather rough texture of the wood but also by their narrower, more pointed buds in winter and, in summer, by their somewhat longer, narrower leaves with pointed, acuminate tips. On the bushes they have flowered more profusely than either the Angers or the Pillnitz varieties, although they were undoubtedly outmatched in this respect by the extremely prolific Malling D. The flowers are among the largest and most showy of all the quince varieties and open about midway between those of the very early flowering Malling D and the late flowering Angers. The fruits are nearer in size and shape to the so-called edible quinces than are those of the Angers, Pillnitz or Malling D and, indeed, are not unlike those of the Portugal (see Figs. 13 and 16).

While all these four selections of the Provence quince were fairly vigorous and free growing, quite striking differences in size and habit of bush had appeared by the end of the ninth year. Of the four, C54 was outstandingly the most vigorous having made a bush some 12 feet high by 14 feet across, probably the largest quince bush we have ever had at East Malling.

The bushes of C51 and C53 were not greatly inferior to this in size but that of C52 was scarcely half as large and considerably less dense (see Figs. 3 and 4). There has been some variation also in their season of flowering, C51 being somewhat earlier and C53 somewhat later than the others. With regard to the characters of the flowers themselves, those of C53 and C54 had smaller and narrower sepals (see Table VII), while the pistils of the flowers of C51 were pale mauve instead of the usual transparent greenish white. Although the fruits were generally very similar in size and shape, those

* It is of interest, that one of our correspondents, member of a famous firm of French nurserymen, after stating that the pear varieties Passe Crasanne, Dr. Jules Guyot, Beurré d'Anjou, Bonne Louise and Charles Ernest seem to prefer the Quince de Provence, continues: "On the other hand, Williams' Bon Chrétien seems to have little sympathy for this stock and does better on Quince de Fontenay."

of C53 contained fewer seeds and the seeds of both C53 and C54 were rather broader in shape (see Table VIII).

It would have been impossible to distinguish between these quinces from the characters of the shoots arising from the stools. In all the characters relied upon in such identifications, as the shape, colour and pose of leaves and stipules, in the colour and hairiness of the wood, number of lenticels and shape of buds, they were fairly uniform. Nevertheless, there was sufficient evidence of variation in the characters of the bushes to make it clear that they were, in fact, distinct varieties.

5. The Quinces of Fontenay.

The " Cognassiers de Fontenay " appear to be fairly extensively used as pear rootstocks on certain nurseries in France, but the exact significance of the name is still in doubt. Specimens labelled " de Fontenay " were received at East Malling in the early days of the rootstock investigations and, according to Hatton, were very mixed. Two varieties, differing only very slightly from one another, were selected from the mixture and of these one has been retained as Malling D. It has never proved very satisfactory as a rootstock for pears and trees worked upon it have manifested varying degrees of delayed incompatibility.

In the early spring of 1939 we received plants of a variety of quince under the name of Cognassier de Fontenay from a firm of French nurserymen. This variety, referred to in this paper as C39, differed from Malling D in almost every particular. The characters of its shoots, foliage, flowers and fruits resembled very closely those of the Cognassiers de Provence and I have included it among the Provence quinces in this treatment.

6. Malling D.

With its identity still in some doubt it seems better for the present to keep Malling D separate from the quinces of Fontenay, but its characters are included in the tables for comparative purposes.

In its botanical characters it shows many distinctive features. As a bush it has a characteristic low, drooping habit, making a large spreading bush which rarely exceeds five or six feet in height. The young shoots are long and straight and, in winter, are a light yellowish to greenish red with small, conical greyish red buds with much extended and channelled bases. The young shoots appeared fairly susceptible to damage by frost.

Although among the latest of all the quinces to come into leaf, it is regularly the earliest in flower. When fully grown, the bushes are extremely floriferous and are covered with large, conspicuous, whitish flowers. The fruits, which are borne in considerable numbers, are generally smaller than those of the Angers and are rather short, broad and oblate, with a narrow, conical, pointed neck. They are usually covered with a profuse woolly bloom, have a distinct aroma and are mature in late October or early November.

7. The Quinces of Orleans.

It is no unusual thing to come across references to the Cognassiers d'Orleans in the French pomological literature and in correspondence with French nurserymen. Until a few months ago we had never received quinces under this name at East Malling and at least one of our nurseryman correspondents in France had assured us that the Quince of Orleans was merely another name for the Quince of Fontenay. Quite recently we received a few rooted shoots from a nurseryman in Denmark under the name of Quince of Orleans. After a very careful comparison of these stocks with the varieties growing at East Malling, I find that in many of their characters they bear a close resemblance to the Quinces of Provence.

Discussion.

These studies have shown that the quinces in use as rootstocks can be classified into botanical groups, of which the Angers, Provence and Pillnitz may be taken as examples. While each of these groups can be distinguished from the others by broad differences in such characters as habit of growth, colour of wood, season of flowering or shape of fruit, each group usually comprises a number of varieties differing among themselves in many minor respects, though sufficiently similar to give the impression of a common origin. This lends support to the view, expressed by a number of our French nurserymen correspondents, that the Angers, Fontenay and Provence quinces are local races indigenous to certain parts of France where they are naturally reproduced by seed. Seedling forms have been taken into use in commercial pear tree nurseries where they have been multiplied by vegetative means. In this way the numerous, very similar varieties of the Angers and Provence quinces seem to have been introduced into cultivation.

It cannot be assumed that varieties which show little morphological difference will necessarily behave similarly when used as rootstocks. It will clearly be necessary during the next few years to test all the available varieties of Angers, Fontenay and Provence quinces very carefully in the nursery and to reselect the types of proved good performance.

In spite of occasional reports to the contrary, it may, perhaps, be doubted whether any variety of quince exists upon which all varieties of pears will thrive. The writer has experimented with large numbers of quince seedlings, imported from the fruit forests of the Caucasus, and failed to find one which made satisfactory trees when worked with the so-called incompatible pears (Tydeman, 1938). At the same time the early hopes that free pears might be found sufficiently easy rooting to make satisfactory rootstocks have not been entirely fulfilled.

The writer has been interested for some time past in the possibilities of pear—quince hybrids as rootstocks, particularly for those varieties of pear which die out when worked directly on the quince. If the advantages to be obtained from the use of quince and of pear rootstocks could be combined in a single race, the present search for seedling pears which can be readily multiplied vegetatively, and for quinces on which the incompatible varieties of pear will thrive, might be abandoned.

There are already in existence several hybrids between the quince and the pear under the general name of *Pyronia*. At East Malling we have young trees of the graft hybrid *Pyronia danieli*, often called *Pirocydonia* and of *Pyronia luxemburgiana*, a form of *Pyronia veitchii*. It has not yet been possible to try these as rootstocks. Attempts to cross the quince with the pear, made here in 1947, were not successful but they will be repeated.

Acknowledgements.

As stated at the beginning, this work is a continuation of that started by Dr. R. G. Hatton at East Malling in 1914 and he has taken a deep personal interest in its progress. The writer has had the great advantage of Dr. Hatton's experience and advice throughout, for which he tenders his grateful thanks. Various members of the Pomology staff at East Malling have assisted him at different times and special mention should be made of Mr. J. Floor, now on the staff of the Instituut voor Veredeling van Tuinbouwgewassen, Wageningen, Holland.

His thanks are also due to Dr. E. E. Cheesman for much assistance in the compilation of this paper.

The writer acknowledges with pleasure the help and encouragement he has derived from the continued interest of Mr. P. Morton Shand of Bath, whose wide experience of fruitgrowing in France has been ungrudgingly placed at his disposal.

Finally, a word of especial gratitude is due to all those horticulturists and nurserymen on the Continent without whose willing co-operation and interest this study would not have been possible and who contributed without stint not only the material upon which it is based but the fruits of their rich and varied experience.

Summary.

Varieties of quince sent to East Malling from nurseries on the Continent are described in detail.

An account is given of the quinces of Fontenay, Pillnitz and Provence and of some new forms of the Angers.

The probable mode of origin of the numerous continental quinces is discussed.

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Table I.

Characters of the Bushes in Winter.

	Angers.	Malling C.	Pillnitz.	Provence.	Malling D.
Vigour	Variable, usually fairly vigorous.	Very dwarfed and weak growing.	Not usually very vigorous.	Variable, usually very vigorous.	Fairly vigorous.
Habit	Fairly erect, very dense.	Very erect and dense.	Fairly erect, very dense and bushy.	Fairly erect and dense.	Very spreading, drooping and rather thin.
Older Branches	Not very stout, dull greyish brown, fairly smooth to the touch, with some indistinct rust-coloured lenticels.	Not at all stout, dull slaty grey to greyish brown, smooth to the touch with some small, indistinct rust-coloured lenticels.	Fairly stout, greenish to greyish brown, fairly smooth to the touch, densely covered large irregular rust-coloured lenticels.	Stout, greenish to greyish brown, rather rough to the touch with many large rust-coloured lenticels.	Fairly stout, dull slaty grey to greyish brown, smooth and even to the touch, with some rather indistinct, rust-coloured lenticels.
Young Shoots Strength	Not very long, slender, internodes often shortish, zigzagged.	Short, erect, slender and wiry.	Somewhat short and slender, internodes fairly long, usually distinctly zigzagged.	Not very long, stoutish, upturned, internodes long and straight.	Of medium length, fairly slender and drooping, internodes fairly long, quite straight.
Colour	Deep greenish or greyish to chocolate brown.	Deep reddish to chocolate brown.	Variable, usually greenish to chocolate brown.	Dull greenish to chocolate brown.	Pale yellowish or greenish brown streaked with red.
Pubescence	Very little.	Very little.	Only occasional small patches of grey pubescence.	Densely covered with a profuse whitish pubescence often with some short erect silvery hairs.	Very little.
Texture	Often very slightly striated, smooth to the touch.	Smooth and shiny.	Quite smooth and shiny.	Somewhat rough.	Quite smooth to the touch.
Lenticels	Deep putty colour (not raised above the surface).	Dark putty colour (not raised above the surface).	Deep brownish orange (not raised above the surface).	Deep putty colour (usually slightly raised).	Dull brown (not raised above the surface).
Buds Shape	Very broadly conical, plump and almost globose.	Rounded, globose.	Broadly conical to almost globose.	Medium conical.	Short and broad, flattish conical.
Apex	Obtuse and rounded.	Broad, rounded.	Broad and rounded.	Fairly acutely pointed.	Broad, rounded, obtuse.
Colour	Deep brownish crimson much flecked with grey.	Dull brownish crimson flecked with grey.	Deep brownish crimson much flecked with grey.	Deep brownish vermilion flecked with grey.	Dull crimson flecked with grey.
Hairiness	Densely covered short, erect, silvery coloured hairs.	Many short, erect, silvery hairs near the apex.	Usually covered with short, erect, silvery coloured hairs.	Usually with some short, erect, silvery coloured hairs towards the apex.	Covered with short, silvery coloured hairs.
Scales	Somewhat loosely arranged.	Somewhat loosely arranged.	Not very compactly arranged.	Somewhat loosely arranged.	Fairly tightly wrapped.
Position	Slightly protruding away from shoots.	Closely adpressed to the shoots.	Tips of buds slightly protruding from shoots.	Closely pressed against the shoot.	Closely pressed against the shoot.
Bud base	Only slightly extended, shallowly channelled into three small knobs.	Somewhat extended and shallowly channelled into three reddish knobs.	Only slightly extended, shallowly channelled into three small knobs.	Not usually much extended, shallowly channelled into three reddish coloured knobs.	Much extended, deeply channelled into three large, distinct knobs.
Frost Susceptibility	Fairly severely damaged.	Usually very little damaged.	Some frost damage but markedly less than on Provence varieties.	Usually severely damaged.	Fairly severe.

Table II.

Characters of the Bushes in Summer.

	Angers.	Malling C.	Pillnitz.	Provence.	Malling D.
Time of Leafing Out	Latish	Latish.	Latish.	Fairly early.	Very late.
Colour of Youngest Foliage	Bright yellowish green.	Bright golden yellow.	Pale yellowish green with much whitish pubescence.	Pale pea green with much whitish woolly pubescence.	Bright grass green.
Season of Defoliation	Usually latish.	Usually latish.	Very variable, usually fairly early.	Latish	Fairly early.
Young Shoots Strength	Variable, usually fairly long and slender.	Dwarfed, very compact and dense, shoots very short and slender.	Not very long, slender and wiry.	Usually shortish and fairly stout.	Long, slender.
Colour	Pale yellowish green streaked with brownish red, lower parts deep chocolate brown.	Deep grass green to dull greenish brown.	Pale yellowish green with purplish red streaks, deep greenish to chocolate brown towards base.	Pale green streaked with purplish red, deep greenish to greyish brown towards base.	Pale green with streaks of brownish red.
Pubescence	Some fine, white, powdery-looking pubescence.	Some fine, white, powdery-looking pubescence.	Upper parts covered with a faint, white, powdery-looking pubescence.	Dense, white, powdery-looking pubescence especially towards tops of shoots.	Covered with white, powdery-looking pubescence almost to base.
Lenticels	Fairly numerous, conspicuous, circular, orange.	Numerous, small, circular, orange.	Numerous, inconspicuous, circular, orange.	Very numerous, usually conspicuous, circular, orange.	Fairly numerous, small and inconspicuous, circular, orange.
Leaves. Shape	Broadly ovate, often almost circular.	Little longer than broad, broadly ovate or almost circular.	Broadly oval.	Broadly elliptical to medium oval.	Considerably longer than broad, broadly elliptical or medium oval.
Apex	Tapering abruptly to a slightly drawn out, acuminate apex.	Tapering to a rather obtuse apex.	Tapering abruptly to a rather broad, obtuse apex.	Tapering abruptly to a slightly drawn out, acuminate tip.	Gradually narrowing to an obtuse, almost rounded apex.
Margin	Usually broadly and shallowly undulating.	Undulating in short, narrow waves.	Only slightly undulating in short, shallow waves.	Undulating in rather narrow, shallow, even waves.	Broadly undulating.
Surface	Shallowly upfolded, margins usually raised.	Deeply upfolded, often rather crinkled.	Shallowly upfolded or upcupped but often rather flat.	Shallowly upfolded, often almost flat.	Usually slightly upfolded.
Colour	Younger leaves bright yellowish green; older leaves deep olive green.	Pale yellowish green often mottled.	Younger leaves bright yellow green; older leaves deep olive green.	Younger leaves rather pale grass green; older leaves deep bluish green.	Younger leaves pale green; older leaves dark olive green.
Pubescence	Upper surface almost glabrous, under surface covered with short, white, felted hairs.	Rather sparsely covered with short, white, downy hairs on under surface.	Young leaves covered on both surfaces with soft, white pubescence; older leaves usually glabrous above with soft, white, woolly hairs beneath.	Young leaves covered on both surfaces with a dense, white, woolly pubescence; older leaves usually glabrous above with dense, white, felted hairs on under surface.	All but the oldest leaves covered on both surfaces with soft, white, downy hairs.
Veins	Tinged red on under surface.	Usually green.	Usually tinged red on under surface.	Slightly tinged red on under surface.	Rarely tinged red.
Pose	Somewhat downturned, often rather twisted.	Petioles rather erect, laminae slightly downturned, curved over.	Held out horizontally, tips usually downturned.	Held out horizontally with tips slightly downturned.	Held stiffly outwards or very slightly drooping.
Stipules	Broadly lanceolate, distinctly serrate, erect and closely pressed to shoots.	Frequently absent. When present, lanceolate, pointed, margins entire, tinged red at base, rather spreading.	Frequently lacking; when present, broadly lanceolate, faintly serrate, often downfolded, erect or inclined a little outwards.	Broadly lanceolate, faintly but distinctly serrate, margins often appear frilled, deeply upfolded, erect but tips often spreading.	Broadly lanceolate or triangular, distinctly serrate, margins often upfolded and frilled, slightly spreading.

Table III.

Characters of the Flowers.

	Angers.	Pillnitz.	Provence.	Malling D.
Unopened Buds				
Shape	Narrowly ovate.	Narrowly ovate.	Narrowly lanceolate or conical.	Conical.
Apex	Fairly acute.	Not usually very acutely pointed.	Tapering gradually to an acutely pointed apex.	Broad and rounded.
Colour	Deep rose pink with spirals of darker pink.	Deep rose pink.	Bright salmon pink with spirals of deeper pink.	Pale salmon pink.
Petal arrangement	Rather loosely arranged, edges of petals slightly raised.	Not very compactly folded, edges of petals often slightly raised.	Very tightly wrapped.	Often rather loosely arranged.
Sepals	Long, narrow, liguliform, green.	Short and narrow, liguliform, turned directly downwards.	Short and narrow, turned directly downwards.	Broad and leaflike, often spreading.
Expanded Flowers				
Habit	Flowers very sparse, on short pedicels up to 4 mm. long, fairly stout, densely covered with short, soft, white hairs.	Not generally very floriferous. Flowers on short, rather stout pedicels covered with short, white hairs.	Variable but usually fairly floriferous. Flowers on pedicels up to 10 mm. long, fairly stout and densely covered with long, whitish, matted hairs.	Extremely floriferous. Flowers on shortish, stout pedicels covered with short, white hairs.
Shape	Shallowly cup-shaped when fully expanded, petals slightly imbricate at base.	Shallowly cup-shaped when fully expanded, petals slightly imbricate at base.	Shallowly cup-shaped often almost flat when fully expanded, petals slightly imbricate at base.	Shallowly cup-shaped or almost flat when fully expanded, petals much overlapping.
Size	Small, usually less than 40 mm. across.	Usually rather small, rarely more than 40 mm. across.	Fairly large, up to 60 mm. across.	Large, 70 mm. or more across.
Sepals				
Shape	Short and narrow, lanceolate or liguliform.	Narrow, leaflike, lanceolate or liguliform.	Long, narrow, leaflike, liguliform or lanceolate.	Narrowly oval, tapering to a fairly acute apex.
Colour	Deep green.	Deep green.	Deep green.	Light green.
Pose	Turned directly downwards.	Turned directly downwards.	Usually turned directly downwards.	Often rather spreading.
Petals				
Colour	Pale rose with faint streaks of deeper pink.	Pale rose pink with patches of deeper pink.	Palest rose pink with large patches of deeper pink, veins often conspicuously tinged deep red.	White with faint streaks of pale pink.
Shape	Obovate or irregularly obconical, apex flattened usually with a shallow notch, one side often higher than the other, tapering abruptly at the base to a narrow claw.	Obovate or almost obconical, apex broad and flat but rarely notched, tapering to a short claw.	Obovate or irregularly oblong, apex somewhat flattened usually with a shallow notch, tapering to a short rounded claw at base.	Obovate or irregularly oblong, broad at top with a shallow notch, tapering to a short, rounded claw.
Surface	Deeply concave.	Shallowly concave.	Shallowly concave when fully expanded.	Shallowly concave.
Margin	Finely frilled.	Finely and evenly frilled.	Often finely and irregularly frilled.	Faintly and narrowly frilled towards the base.
Stamens	Erect.	Usually rather spreading.	Erect or slightly spreading.	Often rather spreading.
Pistils	Some long, soft, white hairs right at base.	Lower parts densely covered long, soft, white hairs.	Lower parts densely covered long, white, woolly hairs.	Some long, white, soft hairs towards the base.
Receptacle				
Calyx ring	Fairly deep and wide, lined with short, pale, felted hairs.	Shallow and narrow, lined with short, pale, felted hairs.	Fairly deep and wide, lined with short, white, felted hairs.	Fairly deep and wide, lined with short, pale, felted hairs.
Size	Smallish.	Smallish.	Fairly large.	Large.
Season of Flowering	Late.	Late.	About midseason.	Very early.

Table IV.

Characters of the Fruit.

	Angers.	Pillnitz.	Provence.	Malling D.
Fruitfulness of Bush	Not very fruitful.	Not very fruitful, except C49.	Fairly fruitful.	Very fruitful.
Characters of Fruit				
Size	About medium size.	Variable, usually very small.	Fairly large.	Variable, usually rather small.
Shape	Globular or flattish oblate, usually about as long as broad, narrowing slightly towards the eye.	Very irregular, flat and oblate.	Broadly conical, tapering abruptly from a broad, rounded base to a narrow, rounded apex but very irregular.	Usually pyriform, tapering from a very large, rounded base to a short, narrow, often pointed apex.
Ribs	Distinctly broadly ribbed, particularly towards base.	Distinct and narrow extending the whole length of the fruit.	Broad and distinct.	Broadly and irregularly ribbed; ribs often extending right down the fruit.
Surface	Smooth, shiny and clear with very little pubescence.	Smooth with a little thin, greyish brown, woolly pubescence.	Rather uneven, covered with a dense, felted, greyish or brownish, soft, woolly pubescence.	Often with a profuse, grey, woolly pubescence.
Colour	Pale pea green, changing to clear lemon yellow with a few scattered russet dots.	Dirty, dingy green changing to a dull primrose yellow with patches and dots of smooth brown russet.	Bright pea green changing to a clear primrose yellow with occasional faint russet dots.	Deep bluish green changing to a dull lemon or primrose yellow with large patches of smooth, brown russet and numerous tiny, faint, russet dots; generally rather dingy.
Sepals	Rather short, narrow and persistent.	Long, broad and persistent.	Long, narrow, persistent.	Fairly long, broad and persistent.
Basin	Deep, wide, conical, slightly ribbed.	Very shallow, much ribbed and puckered.	Deep, wide, conical, distinctly ribbed.	Deep, wide, conical, slightly ribbed and puckered.
Stalk	Short and stout often almost buried in cavity.	Very short and stout.	Very short and stout, often entirely filling the cavity.	Short and stout, often inserted at an angle, usually continuous.
Cavity	Shallow, narrow, usually slightly russetted, surmounted by a narrow, raised ring which usually remains green in the ripe fruit.	Very shallow and narrow, edges raised in irregular lumps.	Shallow and narrow, often appearing as a narrow, uneven, raised rim surrounding the stalk.	Usually absent.
Core	Large.	Very large, occupying almost the whole of the fruit.	Fairly large.	Large.
Seeds				
Shape	Variable, usually lanceolate or narrowly ovate, tapering to a rather obtuse apex.	Broadly conical; tapering gradually to an obtuse apex.	Medium ovate, tapering gradually to a rather blunt apex.	Conical or narrowly ovate.
Colour	Pale chocolate brown.	Bright chocolate brown, those of C49 much paler.	Deep chocolate brown.	Bright chocolate brown.
Flesh Colour	Yellowish white.	Deep, rich yellow.	Deep yellow.	Yellowish white.
Aroma	Fairly distinct.	Usually very indistinct but C49 is very strongly scented.	Very indistinct.	Distinct.
Season of ripening	Variable, usually fairly early, October.	Early, October or early November.	Fairly late, November to December.	Midseason, late October to November.

Table V.

Characters of the Bushes in Winter.

	Strength of Growth.			Dimensions of Buds.		No. of lenticels on 1 cm. of wood.		
	No. of observations.	Average length of shoots. cm.	Average diameter of shoots. cm.	Length of internodes. cm.	Average Length. cm.	Average Breadth. cm.	Near Base.	Near Apex.	Average.
I. Quince of Angers									
Malling A	50	32·5	0·34	2·3	0·25	0·23	20	12	16
Malling B	50	32·1	0·33	2·1	0·21	0·22	16	13	15
C28	50	32·0	0·32	2·0	0·24	0·22	21	15	18
C30	50	28·3	0·31	1·5	0·29	0·27	15	11	13
II. Malling C and Related Quinces									
Malling C	50	14·5	0·26	1·4	0·16	0·17	18	14	16
C29*	50	11·6	0·20	1·3	0·16	0·15	13	12	12
III. Quince of Pillnitz									
C46 R1	50	31·6	0·34	2·2	0·25	0·22	17	13	15
C47 R2	50	36·5	0·37	2·5	0·29	0·21	23	20	22
C48 R3	50	29·7	0·28	2·0	0·23	0·24	14	11	13
C49 R4	50	31·4	0·36	2·7	0·26	0·24	12	10	11
C50 R5	50	33·9	0·35	1·8	0·24	0·21	16	8	12
IV. Quince of Provence									
C51	50	30·7	0·40	2·7	0·38	0·23	20	12	16
C52	50	41·5	0·43	2·9	0·35	0·20	19	12	16
C53	50	48·0	0·47	2·7	0·39	0·29	24	15	20
C54	50	60·4	0·57	2·9	0·31	0·24	26	19	22
C39†	50	33·6	0·37	2·7	0·32	0·22	29	12	21
V. Malling D	50	37·2	0·32	3·3	0·36	0·19	23	15	19

* Received as Quince of Angers.
† Received as Quince of Fontenay.

Table VI.

Characters of the Foliage Leaves.

	No. of observations.	The Lamina.		The Petiole.	The Stipules.	
		Average Length. mm.	Average Breadth. mm.	Average Length. mm.	Average Length. mm.	Average Breadth. mm.
I. Quince of Angers						
Malling A	50	47	35	7	9	4
Malling B	50	43	33	6	8	3
C28	50	45	34	6	9	3
C30	50	42	33	5	9	4
II. Malling C and Related Quinces						
Malling C	50	40	31	5	–	–
C29	50	34	32	5	–	–
III. Quince of Pillnitz						
C46 R1	50	49	35	7	8	3
C47 R2	50	40	31	6	8	3
C48 R3	50	46	35	5	8	3
C49 R4	50	52	38	7	9	3
C50 R5	50	45	36	6	8	3
IV. Quince of Provence						
C51	100	52	38	7	10	4
C52	100	52	37	7	10	4
C53	100	56	40	8	9	4
C54	100	54	37	7	10	4
C39	50	48	34	7	9	4
V. Malling D	50	50	37	6	8	3
Malling E	50	56	45	9	12	4
Malling F	50	54	41	9	11	4
Malling G	50	49	38	8	9	3

Table VII.

Characters of the Flowers.

	No. of observations.	Dimensions of the Petals.		Dimensions of the Sepals.	
		Average Length mm.	Average Breadth. mm.	Average Length. mm.	Average Breadth. mm.
I. Quince of Angers					
Malling A	70	18	13	9	3
Malling B	70	20	13	10	4
C28	70	16	11	11	4
C30	100	17	13	9	3
III. Quince of Pillnitz					
C46 R1	40	18	12	9	3
C47 R2	50	17	11	11	3
C49 R4	100	22	17	13	5
IV. Quince of Provence					
C51	100	26	20	14	7
C52	100	25	19	14	7
C53	100	23	16	13	5
C54	100	26	18	12	5
C39	100	26	19	14	6
V. Malling D	100	27	20	14	7
Malling E	100	26	24	16	8
Malling F	100	26	21	17	8
Malling G	100	24	19	17	7

Table VIII.

Characters of the Fruit.

	Number of Fruits Examined.	Dimensions of the Fruits.				Dimensions of the Core.						Dimensions of the seeds.		
		Greatest Length. mm.	Greatest Breadth. mm.	Least Breadth. mm.	Depth of Basin. mm.	Length. mm.	Breadth. mm.	Height. * mm.	Distance.† mm.	Length of the locules. mm.	Breadth of the locules. mm.	Length. mm.	Breadth. mm.	Number.
III. Quince of Pillnitz														
C46 R1	50	31·4	37·1	20·2	2·3	13·8	19·3	11·5	8	7·9	7·5	7·4	4·5	32
C48 R3	42	32·1	37·2	22·4	3·7	13·1	16·1	11·6	11	7·3	7·2	7·2	4·4	25
C49 R4	35	70·0	53·7	16·9	6·7	21·6	26·2	34·3	14	9·4	8·7	7·5	4·3	27
IV. Quince of Provence														
C51	50	73·5	60·9	21·5	11·8	23·4	27·9	38·5	15	10·7	10·5	8·3	4·4	52
C52	50	69·3	58·7	20·9	9·0	23·1	27·6	35·7	15	10·0	9·7	8·2	4·4	54
C53	50	69·6	62·5	20·2	11·0	21·2	28·4	36·1	16	10·1	9·1	8·5	5·1	32
C54	50	67·4	61·4	22·0	11·9	21·1	29·6	34·5	16	10·0	9·7	8·3	5·3	47
C39	50	76·1	61·6	19·9	14·0	23·1	29·7	39·9	16	10·8	9·7	8·4	4·5	50
V. Malling D	50	61·1	52·7	10·8	8·5	21·0	26·1	30·3	13	10·0	9·4	8·0	4·4	41
Malling F	50	76·1	65·1	21·9	14·7	23·6	27·0	38·6	20	9·1	8·7	8·2	5·4	31
Malling G	7	77·8	70·6	23·7	15·4	21·4	26·1	37·8	22	9·4	8·6	8·3	5·7	37

* Distance from top of core to top of fruit.
† Distance from edge of core to edge of fruit.

Table IX.

Significance of Differences in Size and Shape of Certain Organs.*

	From Table V.		From Table VI.		From Table VII.		From Table VIII.			
	Size of Buds. Breadth as a percentage of length.	*Lenticels.* Number on one cm. of wood.	*Leaves.* Breadth as a percentage of length.	*Petioles.* Length as a percentage of length of lamina.	*Petals.* Breadth as a percentage of length.	*Sepals.* Breadth as a percentage of length.	*Fruit.* Breadth as a percentage of length.	*Core.* Breadth as a percentage of length.	*Locules.* Breadth as a percentage of length.	*Seeds.* Breadth as a percentage of length.
I. Quince of Angers										
Malling A ..	97·9	15·8	74·8	14·0	69·9	36·6				
Malling B ..	104·4	14·2	76·0	13·6	67·8	37·5	—	—	—	—
C28	95·0	18·2	76·4	14·4	72·3	35·5	—	—	—	—
C30	96·9	13·0	77·8	11·6	70·5	35·9	—	—	—	—
Sig. Diff. ($P=0·05$)	**6·2**	**1·07**	**1·3**	**0·5**	*No differences are significant.*		—	—	—	—
II. Malling C and Related Quinces										
Malling C ..	106·4	15·9	77·5	13·2	—	—	—	—	—	—
C29	90·6	12·6	84·1	15·6	—	—	—	—	—	—
Sig. Diff. ($P=0·05$)	**3·7**	**1·07**	**1·7**	**0·5**						
III. Quince of Pillnitz							119·4	144·1	96·0	58·9
C46 R1 ..	87·7	15·0	71·7	13·3	67·7	32·0	—	—	—	—
C47 R2 ..	73·4	21·6	77·6	14·0	66·7	30·6	118·9	127·2	100·1	61·8
C48 R3 ..	95·8	12·4	77·1	12·0	—	—	79·2	123·1	92·8	57·9
C49 R4 ..	93·6	10·9	74·4	13·0	79·2	37·6	—	—	—	—
C50 R5 ..	87·0	11·7	77·4	13·3	—	—	**4·5** (*approx.*)	**10·5** (*approx.*)	*No differences are significant.*	
Sig. Diff. ($P=0·05$)	**6·2**	**1·07**	**1·2**	**0·5**	C46 *and* C47 *do not differ significantly* C49 *is significantly greater than either.*					
IV. Quince of Provence										
C51	62·6	15·8	73·0	13·6	76·6	52·9	83·1	121·5	99·0	53·1
C52	61·8	15·6	71·7	14·2	77·2	46·6	84·9	121·8	97·8	53·8
C53	76·4	19·6	71·4	14·3	72·5	42·2	90·1	135·8	87·5	60·3
C54	78·9	22·3	70·4	13·8	70·3	44·8	91·7	143·2	99·2	56·1
C39	69·9	20·6	71·6	14·4	72·7	41·6	81·8	130·8	91·5	54·2
Sig. Diff. ($P=0·05$)	**6·2**	**1·07**	**0·8** (*approx.*)	**0·4**	**2·0**	**3·4**	**3·2**	**9·1**	*Only* C53 *differs significantly.*	**3·9**
V. Malling D	55·0	18·9	74·0	11·8	75·0	48·9	86·2	127·3	92·3	57·6
Malling E	—	—	81·4	16·4	91·1	48·4	—	—	—	—
Malling F	—	—	76·9	17·0	79·5	46·4	85·3	116·5	96·8	65·6
Malling G	—	—	76·1	16·3	78·7	42·7	—	—	—	—
Sig. Diff. ($P=0·05$)			**1·7**	**0·5**	**2·0** (*approx.*)	G *differs significantly from* E *and* F				

* The writer is indebted to Mr. J. Taylor of the Statistics Section for calculating the data on significance contained in this Table.

Fig. 1.
Quince of Angers. C28. Illustrating habit of growth.

Fig. 2.
Quince of Pillnitz. R5. Illustrating habit of growth.

[*face p.* 64

FIG. 3.
Quince of Provence. C53. Illustrating habit of growth.

FIG. 4.
Quince of Provence. C52. Illustrating habit of growth.

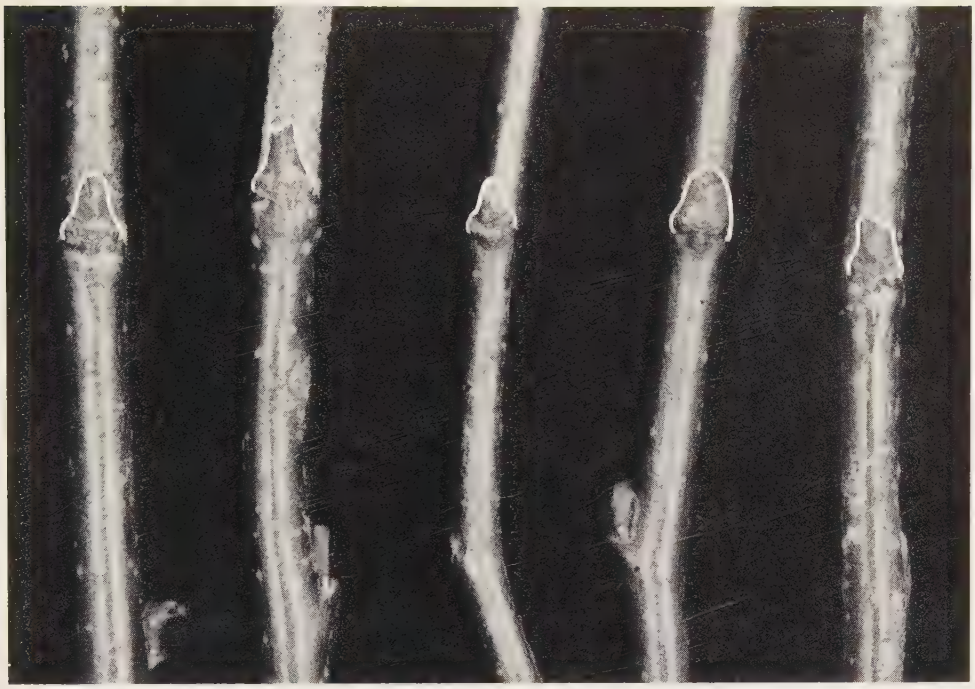

FIG. 5.

Characters of the shoots in winter. Left to right : Malling A ; C28 ; C29 ; C30 and Malling B.

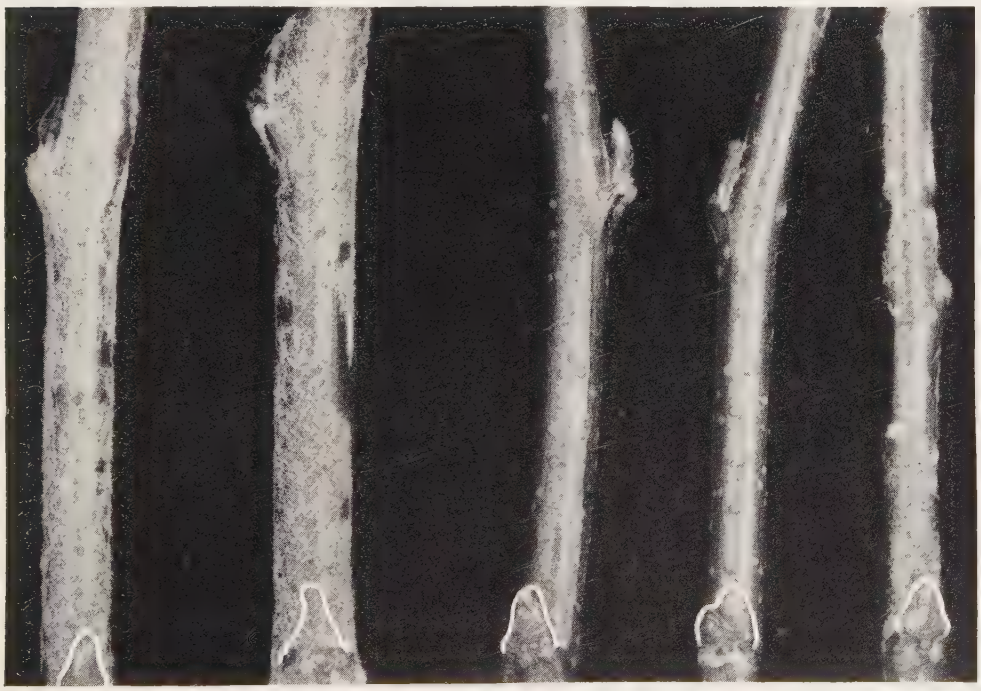

FIG. 6.

Characters of the shoots in winter. Left to right : Quince of Provence C53 and C52 ; Quince of Pillnitz R1, R4 and R5.

FIG. 7.

Characters of the flowers. Quince of Provence. C51 (left) and C52 (right).

FIG. 8.

Characters of the flowers. Quince of Pillnitz R4 (left) and Quince of Provence C39 (right).

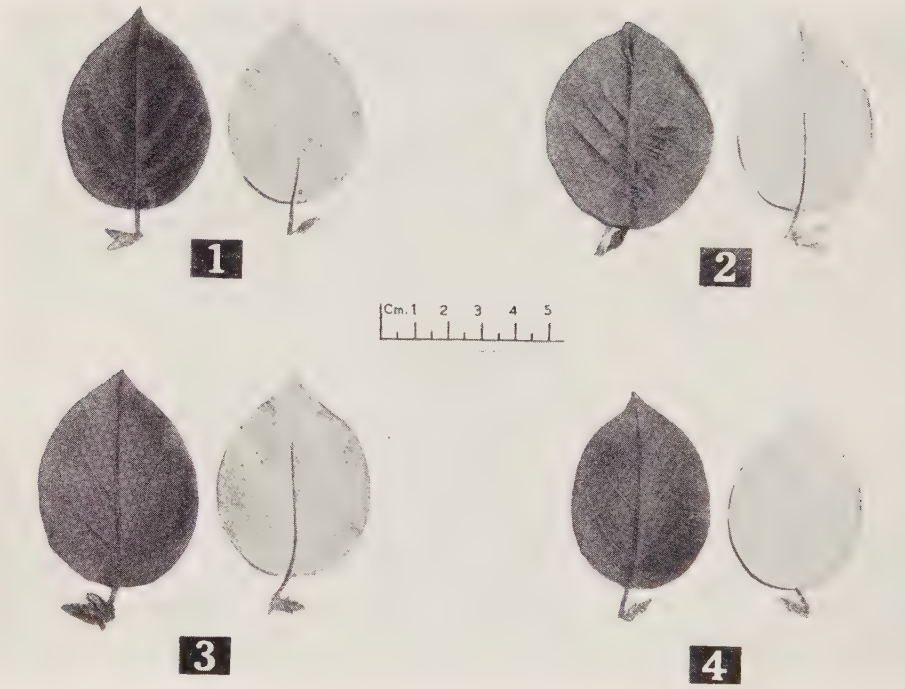

FIG. 9.
Characters of the foliage leaves. Four types of Quince of Provence.

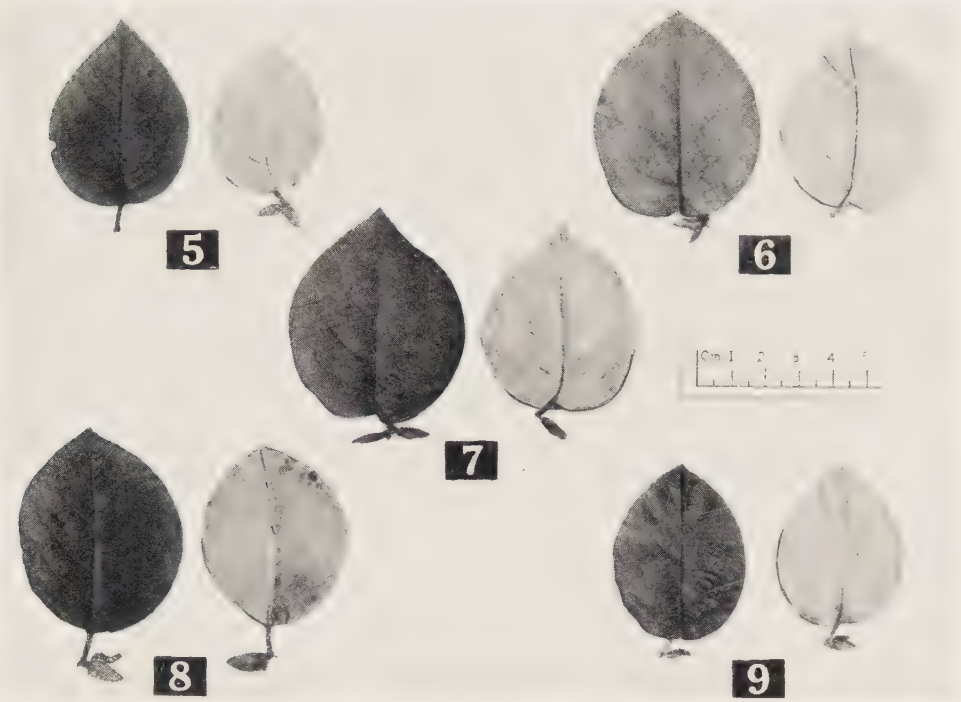

FIG. 10.
Characters of the foliage leaves. Five types of Quince of Pillnitz.

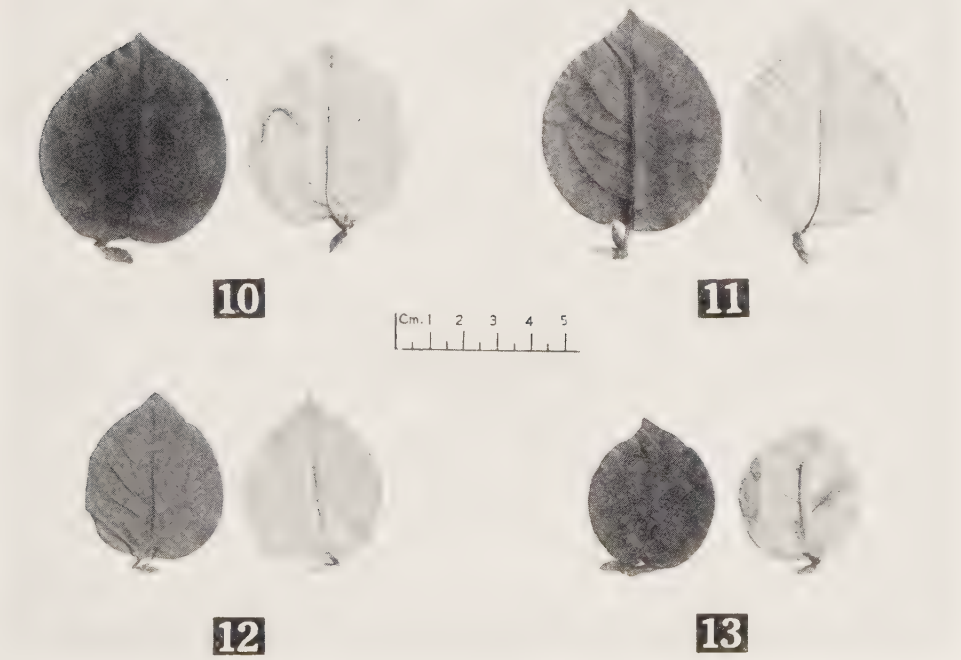

FIG. 11.
Characters of the foliage leaves. (10) Malling A ; (11) C28 ; (12) C29 ; (13) C30.

Fig. 12.

Characters of the summer shoot. Quince of Provence C53.

FIG. 13.
Characters of the fruits. Fruits of four types of Quince of Provence.

FIG. 14.
Characters of the fruits. Fruits of three types of Quince of Pillnitz. (5) R1 ; (6) R3 ; (7) R4.

FIG. 15.

Characters of the fruits. Fruits of types of Quince of Angers. (8) Malling A ; (9) C28 ; (10) C30 ; (11) Malling B.

FIG. 16.

Characters of the fruits. Fruits of Malling D (12) ; E (13) ; F (14) and G (15).

THE NURSERY BEHAVIOUR OF THE WILLIAMS' BON CHRÉTIEN PEAR WHEN WORKED UPON A WIDE RANGE OF QUINCE ROOTSTOCKS

By R. J. GARNER

The benefits obtained by growing pears upon quince are well known and the practice is well established. Nevertheless, whilst the majority of pear varieties grow and crop normally on the quince rootstocks in common use, there are some, including a few valuable commercial kinds, notably Williams' Bon Chrétien, which quite often prove unreliable in combination with the quinces available commercially. This unreliability takes the form of cleavage at the graft-union which normally takes place unexpectedly, often after the tree has become well established in the plantation. Such losses are prevented by double-working in the nursery (Garner and Hammond, 1940). This procedure entails extra work and adds to the cost of the tree.

To obviate double-working and yet provide reliable trees by single-working it would appear necessary to change the customary scion-stock combination. In present usage the scion is already chosen and, beyond the somewhat faint possibility of selecting a strain of the variety which may prove more compatible with quince, consideration must be given to the rootstock and a search made for selections which will behave satisfactorily with Williams' Bon Chrétien and, ideally, with all other pear varieties. A wide examination of all available quinces may well reveal a clone or clones which will support the Williams' Bon Chrétien scion without exhibiting the usual incompatibility.

TABLE I.

NUMBER OF QUINCE SELECTIONS USED AS ROOTSTOCKS AND MAIDENS PRODUCED.

Selection.	No. of individual stool clones.	No. of rootstocks lined out.	Maidens produced.
Quince de Provence C51 ..	4	26	23
,, ,, C52 ..	2	15	15
,, ,, C53 ..	12	63	63
,, ,, C54 ..	6	37	37
Pillnitz R1 C46 ..	18	113	113
,, R2 C47 ..	8	95	95
,, R3 C48 ..	12	85	85
,, R4 C49 ..	8	41	41
,, R5 C50 ..	10	92	92
Quince d'Anger Malling A ..	4	31	31
,, ,, C28 ..	2	25	25
,, ,, C29 ..	2	3	3
,, ,, C30 ..	1	2	1
Quince de Fontenay Malling D ..	5	27	23
,, ,, C39 ..	3	12	12
Quince Malling B	3	23	23
,, ,, C	2	8	5
,, ,, G	2	14	14
South American Quince	4	43	42
Quince Malling A	—	20	20
,, ,, B	—	20	20
,, ,, C	—	20	18
,, ,, D	—	20	20
,, ,, E	—	20	20
,, ,, F	—	20	20
,, ,, G	—	20	20
Totals	108	895	881 (98%)

Material.

In order to study the variation in quinces used as rootstocks for pears a collection was established at East Malling alongside the seven clones, Quinces A to G, already described and tested (Hatton, 1928). The preceding article by Mr. Tydeman provides a detailed description of the quinces in this collection, with the exception of some raised from seed, obtained from Uruguay and stooled at East Malling. One plant from each batch of quinces received was unpruned and the others were, upon establishment, cut down to form stools for further propagation.

TABLE II.

HEIGHT OF TREES IN DECIMETRES, FRUIT BUDS AND TREE SURVIVAL.

Selection.	Stool No.	Trees.	Height 1st year.	Trees.	Height 2nd year.	Trees.	Height 3rd year.	Fruit Buds per metre height.	% tree survival.
Quince Malling E ..	—	20	12·9	20	16·1	19	19·7	32·5	95
Quince Malling A ..	—	20	12·1	18	15·6	18	20·1	32·1	90
Pillnitz R3	22	11	11·1	11	14·1	11	18·4	29·6	100
,, R2	20	15	11·8	11	15·7	11	18·3	28·8	73
,, R3	12	9	11·5	9	15·7	9	18·4	28·8	100
,, R5	9	12	11·9	12	13·9	12	19·3	28·8	100
,, R1	11	11	12·0	11	15·4	11	18·6	27·9	100
Quince Malling B ..	—	20	10·9	19	14·8	19	18·6	26·6	95
Quince Malling D ..	—	20	12·0	20	15·7	19	19·1	25·2	95
South American Quince ..	65	14	13·1	13	17·1	12	22·0	25·2	86
Pillnitz R2	10	14	11·5	14	14·6	13	19·6	24·3	93
Angers C28	2	15	11·5	15	14·6	14	18·2	23·2	93
Pillnitz R5	19	14	11·5	14	15·6	14	19·8	22·1	100
,, R1	25	10	11·0	10	14·3	10	17·9	21·9	100
Quince Malling G ..	—	20	12·4	20	15·7	17	20·0	21·6	85
Angers C28	6	10	9·7	10	10·9	10	12·6	21·5	100
Pillnitz R2	19	14	11·0	14	15·1	12	18·4	21·1	86
,, R5	27	12	11·1	12	15·1	12	18·5	21·1	100
,, R1	22	13	11·1	13	14·5	13	17·7	19·9	100
,, R2	23	14	12·5	14	16·7	13	19·9	19·8	93
,, R2	5	17	12·1	17	15·9	17	19·5	18·9	100
Provence C51	7	14	12·3	14	15·5	14	18·9	17·5	100
Pillnitz R3	17	9	10·6	9	14·0	9	17·5	17·1	100
Quince Malling C ..	—	18	10·2	17	14·4	11	16·2	17·1	61
Quince Malling A ..	5	12	11·8	12	13·2	11	16·4	16·5	92
Provence C53	13	8	12·3	8	15·4	8	17·3	15·6	100
,, ,, ...	5	13	11·8	13	15·1	13	19·4	15·2	100
Pillnitz R5	3	13	9·6	13	13·3	12	16·6	15·1	92
Quince Malling F ..	—	20	11·5	19	13·8	18	16·3	14·9	90
Provence C54	19	12	11·4	12	14·0	12	18·3	12·9	100

In the winter of 1942-43 the progeny of individual stools, where sufficiently well rooted, were lined out and in the summer of 1943 they were budded with Williams' Bon Chrétien. The number of individual stools from each batch and the total number of rootstocks lined out are shown in Table I. An additional 20 rootstocks from stoolbeds of each of the Malling quinces A to G were included for comparison, making a grand total of 895.

All the scions were taken from a pair of twenty-two-year-old fruiting trees at the Research Station. All the budding was done four inches above ground by one man, the wood being left in the bud-shield (Garner, 1935). The number of maiden trees produced, given in Table I, shows that the budding was highly successful (over 98 per cent.) and there is no indication that any particular quince is more difficult to bud than any other in these trials, except possibly Malling Quince C, which shows 82 per cent. stand of maidens.

Experimental.

The small size of many of the stool units precludes the drawing of reliable conclusions from them and their amalgamation in the summaries is undesirable because this would fail to reveal the idiosyncrasies of individual stool clones. It has, therefore, been decided to present figures only for those

individual selections in which there are sufficient trees for adequate testing. There are twenty-three of these, in addition to the seven Malling clones A to G.

Growth and Blossoming.

The trees were left unpruned throughout the experiment. The heights of the trees, measured each winter, and the number of blossom trusses recorded in the spring of the third year, are set out in Table II, where the trees are placed in order of blossoming per metre of tree height at blossoming time.

TABLE III.

MEAN VALUES OF PULL IN POUNDS, AT 2 FT., REQUIRED TO BREAK GRAFT JUNCTIONS.

Selection.	Stool No.	Pound pull.*	Selections bracketed do not differ significantly.
Pillnitz R1	11	6·02	
,, R5	27	6·90	
Angers C28	6	7·88	
Malling C	—	8·17	
Pillnitz R5	3	9·22	
Malling A	5	9·48	
Pillnitz R1	25	9·63	
Provence C54	19	9·75	
Malling F	—	10·21	
Pillnitz R1	22	10·35	
,, R2	10	10·42	
,, R3	22	10·49	
,, R3	17	10·73	
,, R2	5	10·79	
Provence C51	7	10·81	
,, C53	5	11·49	
Pillnitz R3	12	11·51	
Malling A	—	11·97	
Angers C28	2	12·01	
Malling B	—	12·20	
Malling G	—	12·59	
Pillnitz R5	19	12·76	
,, R2	19	12·81	
Provence C53	13	13·16	
Malling E	—	13·20	
Pillnitz R2	23	14·11	
,, R2	20	14·52	
Malling D	—	15·61	
Pillnitz R5	9	15·82	
South American Quince	65	17·61	

* After applying a correction for girth 1 in. above and 1 in. below the junction.

There appears to be no general connection between fruit-bud formation and tree height, though it is possibly of some interest to note that trees on the four clones received as Quince de Provence all bloomed comparatively little.

Breakage in the Nursery.

The trees were left unsupported throughout and were exposed to the normal hazards of the nursery. Conforming with the general experience with trees of Williams' Bon Chrétien on quince, a few trees broke at the graft junction either during high winds or when handled during cultivation or recording. Fifteen of the clones survived without loss and ten more lost no more than 10 per cent. of their original number. Of the remaining five clones South American 65 and Pillnitz R2.19 each lost 14 per cent., Malling G 15 per cent. and Pillnitz R2.20 27 per cent., whilst Malling Quince C suffered a severe loss of 39 per cent. and this almost entirely in the third season of growth. Those losses of trees by " natural " breakage are quite unconnected with size of tree, for example, the six trees on Quince C which broke during the third season, had a mean height of 14·8 decimetres at two years old and the survivors 14·1 decimetres.

Breakage in the Laboratory.

In the winter of 1946-47, when the trees were three-years-old, six of each were taken for testing the strength of their union. Only three trees on Malling Quince C were used for this purpose because there were less survivors on this rootstock. Each tree was sawn through at ground level and taken into the laboratory where it was again sawn through six inches above the union and the upper portion of the tree was weighed. The lower part, containing the union, was then fixed in a vice and the trunk girths one inch above and one inch below the union were measured. The formation of the bark at the union was examined to see whether it was continuous or discontinuous (Chang, 1937). In all cases, except for one tree on Provence C53 stool 5, the bark was clearly discontinuous ; this one exception was continuous half-way round and subsequently proved somewhat stronger than the five others of this combination, though no stronger than many of the trees of other combinations.

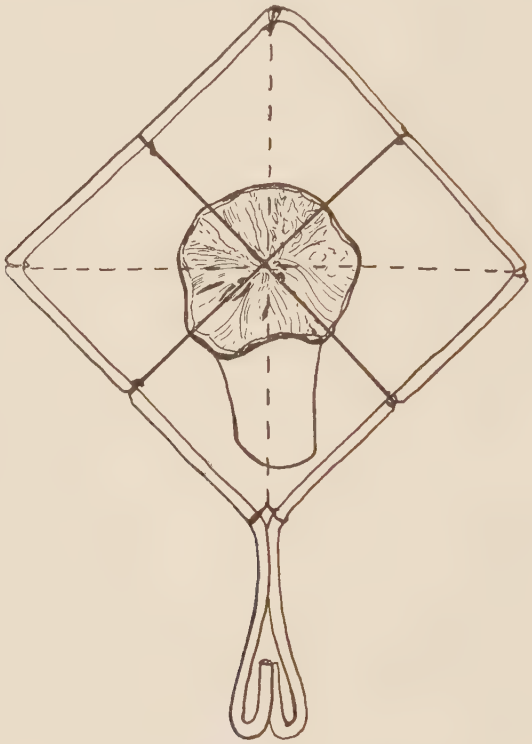

FIG. 1.

Wire frame used to gauge the roughness of the broken surface in four segments. The dotted line indicates the position of coloured thread used as an additional guide to the recorder.

The trunk portion was now placed horizontally in the vice so that the stock portion was held rigidly half-an-inch below the graft junction with the snag wound on the stock facing horizontally away from the operator. A steel tube three feet long was placed over the scion piece (see Fig. 3) so that a wire loop fixed in the side of the tube was 24 inches from the middle of the graft junction. The free end of the tube was suspended by a thin flexible wire from a point directly above the graft junction to keep it horizontal during the operation. A dynamometer was hooked on the wire loop and pulled horizontally, along a curved path, until the union parted. The maximum pull was recorded before resetting the instrument. The nature of the break was observed and noted as " snapped " or " torn ". When the scion piece did not separate completely from the stock it was sawn apart and in further notes the sawn area was regarded as a completely " rough " break. The weight of the scion piece was amalgamated with the weight of the top of the tree.

An examination of the broken surface showed a wide variation in roughness of break and this was recorded as follows : a frame (Fig. 1) with crossed wires was placed over the broken surface of the rootstock portion so that the snag wound was towards the handle. Thus the broken surface was divided into four segments. The segment containing the snag wound was disregarded because this area was somewhat smooth in all trees. Each of the other segments was given points for roughness—

4 for 75 per cent. of the area rough ; 3 for 50 per cent. to 75 per cent. ; 2 for 25 per cent. to 50 per cent. and 1 for less than 25 per cent. Thus the highest possible score was 12 and the lowest 3. Typical broken surfaces may be seen in Fig. 4. As already mentioned, the breaking was always done in the same direction, away from the snag wound, which was thought to be the method requiring least pressure. In order to test this hypothesis, twelve further batches of six trees were taken and broken, two away from the snag wound, two towards the snag wound and two at right angles to the first two directions. The records were analysed and revealed no evidence for differences in roughness of break, either relative to the direction of breaking or relative to the position of the snag wound. Nor did the data show significant differences between the twelve rootstocks in this test.

The mean values of the pull in pounds at two feet from the graft junction are set out in Table III, a correction having been applied (by the method of the analysis of co-variance) for the girth above and

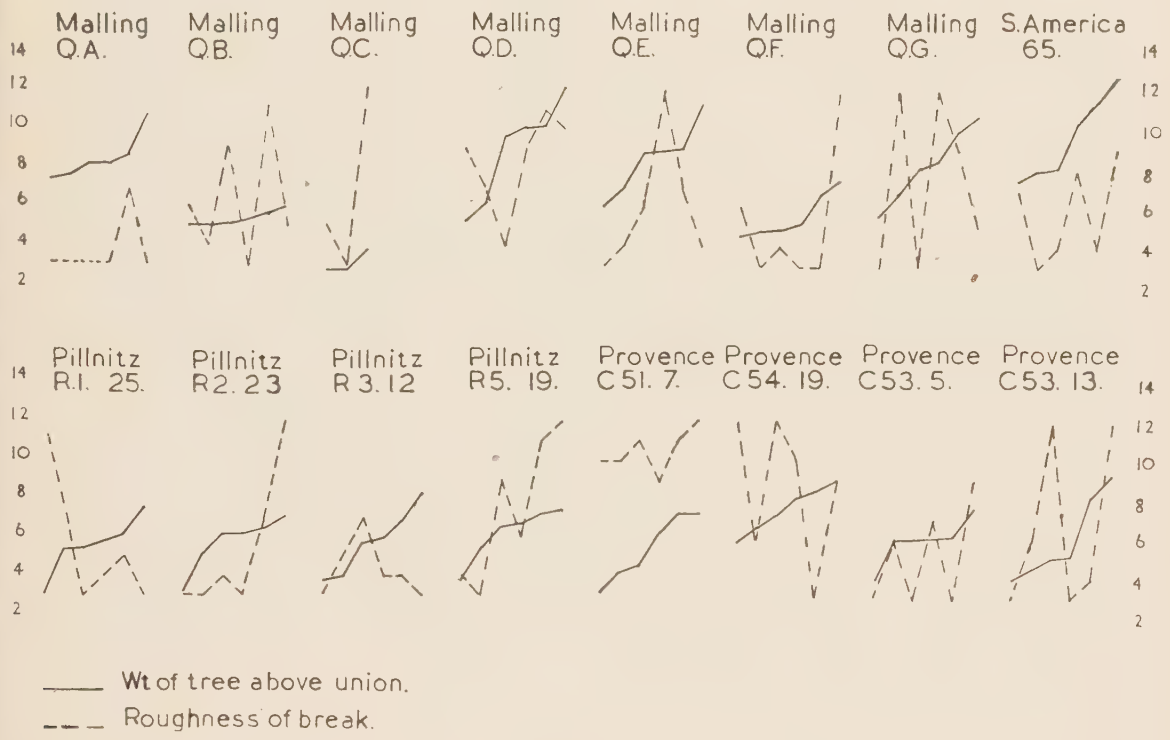

Fig. 2.

Roughness of break and weight of trees above graft junction (in hectogrammes) for sixteen rootstocks.

below the union. The rootstocks are bracketed in groups within which there is no significant difference in pressure required to break. It will be noted that 25 of the 30 rootstocks are enclosed by one bracket and that only one pair of brackets fail to overlap.

To obtain a picture of the values for roughness of break in relation to size in individual clones the individual tree weights and roughness values were plotted in order of tree weight. Fig. 2 depicts sixteen of these graphs and it will be seen that there is a wide variation in type of breaking within each clone with the possible exception of Provence C51 stool 7. It is clear that the roughness or smoothness of the broken surface at the junction bears no relation to the size of the tree.

Discussion.

There are numerous manifestations of stock/scion incompatibility and at least two distinct types are found in pears worked upon quinces. When the pear variety Williams' Bon Chrétien is worked direct on quince the trees, in general, make vigorous healthy growth often coupled with cleavage at the graft junction unaccompanied by any " fading away ". Yet other pears such as the varieties Conference, Fertility and Durondeau grow vigorously and healthily on certain quince rootstocks, but become extremely stunted on others exhibiting a high mortality within a few years of working (Hatton, 1928).

This failure to grow and survive was not, in these last cases, primarily associated with mechanical weakness at the union.

Within fairly wide limits the experiment now reported shows that the variety Williams' Bon Chrétien is unreliable on all the thirty vegetatively propagated clonal quinces so far tested at East Malling and that there is no clearly defined graft affinity for any individual rootstock or rootstocks grouped according either to botanical characteristics or to their origin. This is contrary to the behaviour of the variety Conference (Hatton, 1928), which exhibits distinct preferences for particular vegetatively propagated quinces. The overriding factor in the present experiments has been the Williams' Bon Chrétien scion and there is no clear indication that any of the quinces used will prove reliable for single-working with this variety. At the same time, if one of the clones is to be selected for further trial, there are indications that the Quince de Provence known here as Provence C51 stool 7, which exhibited consistently rough surfaces on breaking, might prove a wise choice.

Acknowledgements.

The Pomology recording staff has been responsible for taking the numerous observations of the material ; thanks are especially due to Miss J. M. Paton for supervising the breakage tests. The help of the Statistical Section in analysing the data is gratefully acknowledged.

Summary.

Thirty quinces, previously collected from the Angers and Provence districts of France, from Germany and from South America were propagated vegetatively, budded with Williams' Bon Chrétien pear and observed for three seasons.

Bud-take, tree height and weight, and fruit-bud formation at two years from working, were not associated with degree of stock/scion compatibility, as revealed by the mechanical strength of, or roughness of the broken surface of, the graft junction.

The Williams' Bon Chrétien pear exhibited no outstanding preference for any particular quince or group of quinces.

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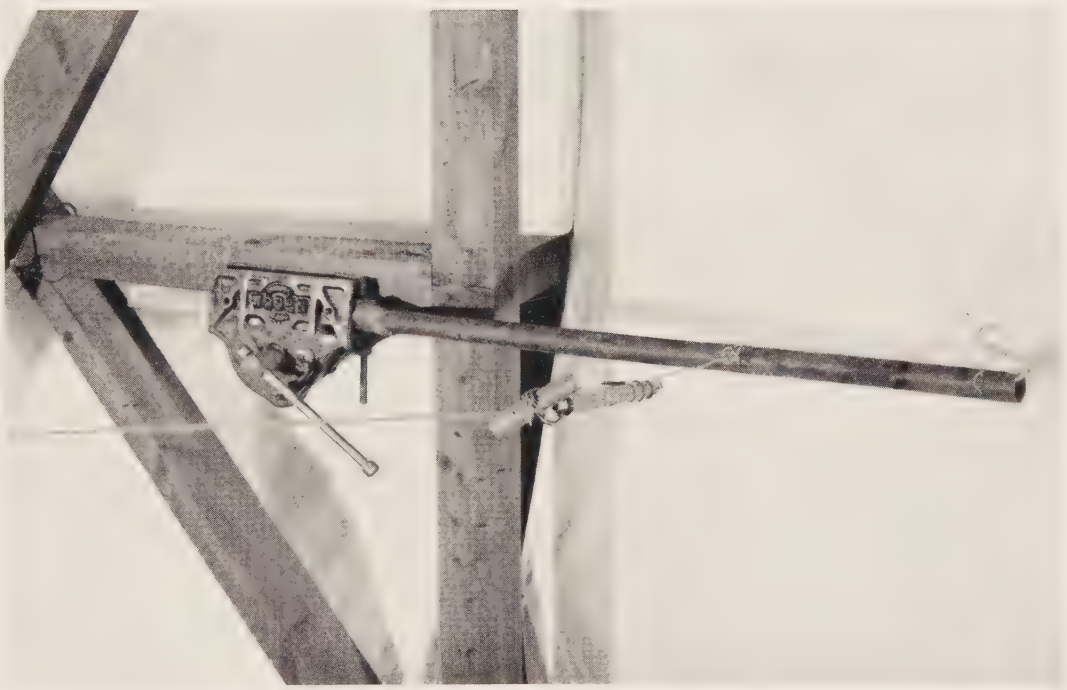

Fig. 3.
Apparatus used to record the pull required to break the graft junction. A thin flexible wire is attached to the right hand end of the tube, holding it horizontal during the operation.

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FIG. 4.
Rootstock portions, after breaking from the scion, showing variations from completely smooth (top left) to fully rough (bottom right). All six specimens Malling G.

THE SELECTION OF HARDWOOD STEM CUTTINGS OF AN APPLE ROOTSTOCK

By R. J. GARNER and E. S. J. HATCHER*

In a review of work done in vegetative propagation by cuttings (Garner, 1944) the source of cuttings was shown to be a very important factor in rooting and it was suggested that studies in the treatment of parent plants and the selection of material from them should have a prominent place in any future propagation research. Consequently, work at East Malling has included experiments along those lines and a report can now be made on some results obtained with apple stem cuttings.

The Test Object.

Difficulty in propagating the vigorous apple rootstock Malling Crab C by normal layering (Garner, 1946) called for an investigation of the possibilities of its multiplication by cuttings. Apples, in general, are notoriously shy to root from cuttings and Malling Crab C is no exception ; but it has proved an excellent test object in propagation and nursery experiments (Hatcher and Garner, 1948) and is now much employed by us for these purposes.

Root v. Shoot Propagated Plants as a Source of Cuttings.

In a study (Stoutemyer, 1937) of apple stem cuttings it was found that shoots arising on roots propagated more readily than shoots from stems and this behaviour was correlated with growth characters, associated with juvenility and maturity respectively.

With a shy-rooting apple, such as Malling Crab C, any improvement in rooting is not only of interest but is also valuable commercially and experiments were designed to test material collected from parent plants which had been raised from roots and from stems.

The first experimental cuttings were planted in November, 1944. They were collected from parent plants of four classes viz. root-propagated, one year old ; root-propagated, two years old ; shoot-propagated, one year old ; shoot-propagated, two years old. All were growing in a drained lake bed, in which also the new cuttings were set. The two year plants had been cut down close to the ground at the end of their first year.

TABLE I.

COMPARISON OF SHOOTS FROM ONE AND TWO YEAR PARENT PLANTS (MEANS OF SAMPLES OF TEN SHOOTS).

	Root-propagated parents.		Shoot-propagated parents.	
	1 year.	2 year.	1 year.	2 year.
Length (cm.)	84	116	85	135
Diameter at middle (mm.) ..	5·5	6·0	5·5	6·9
Buds per shoot*	31	40	32	45
Ratio Length/Diameter ..	153	193	154	196
Ratio Length/Buds* (mm.) ..	24	26	23	27

* Basal 10 cm. of each shoot not included.

Whole yearling shoots were collected by severing at their base, or within half a centimetre above this point. Random ten-shoot samples were taken from each of the four sources and records made of their length, diameter midway along the shoot, and the number of buds (excluding those on the lower 10 cm. of each shoot and the apical buds) (Table I).

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Shoots from the 1 year plants were shorter and relatively thicker than from the 2 year, had more buds in relation to their length, but had fewer buds in relation to their diameter. Age for age the shoots were very similar in externals, though the 2 year shoot-propagated parents gave rise to somewhat larger shoots than those of the same age propagated from roots.

TABLE II.

BEHAVIOUR OF STEM CUTTINGS IN RELATION TO PARENTAL SOURCE (80 CUTTINGS PER TREATMENT).

	Root-propagated parents.				Shoot-propagated parents.			
	1 year.		2 year.		1 year.		2 year.	
	Apical.	Basal.	Apical.	Basal.	Apical.	Basal.	Apical.	Basal.
Grown cuttings	1	17	—	13	—	1	—	14
Living cuttings (not grown)	21	60	10	46	7	18	12	30
Total survival	22	77	10	59	7	19	12	44
		168				82		

Eighty shoots were taken from each source and divided into four lots of 20 to provide replicates. Each shoot was then divided into basal and apical halves and a cutting 12 in. long was made from the base of each half-shoot. Cuttings from the apical and basal half-shoots of each batch of 20 shoots were planted in the same block in the cutting bed which was composed of four blocks, each block containing in random order one of each of the eight batches of cuttings.

After one year the cuttings were recorded as grown, alive but not grown, or dead. The numbers surviving are shown in Table II where it will be seen that root-propagated parents are a better source of stem cuttings than shoot-propagated parents. Furthermore, while 1 year root-propagated parents are a better source than 2 year root-propagated parents, the reverse is shown for the shoot—propagated parents. This accords with the findings of Stoutemyer (1937), Sinha and Vyvyan (1943) and others.

TABLE III.

BEHAVIOUR OF STEM CUTTINGS FROM NON-PRUNED TWO YEAR PARENTS (PERCENTAGES).

	Root-propagated parents.		Shoot-propagated parents.	
	Apical.	Basal.	Apical.	Basal.
Grown cuttings ..	16	21	10	13
Living cuttings (not grown)	9	17	7	7
Total survival ..	25	38	17	20
	31·5		18·5	

Stoutemyer, as already stated, found shoots from roots propagated more readily than shoots from shoots, as in the present experiment. Sinha and Vyvyan, writing of plum cuttings, relate that shoots from 1 year shoot-propagated parents rooted much worse than those from 2 year shoot-propagated parents their figures being 28 per cent. and 47 per cent. respectively. The behaviour of the progeny of shoot-propagated parents set out in Table II bears this out, the values for survival being 24 per cent. for one year parents and 55 per cent. for two year parents.

The striking difference in performance between cuttings from the lower part of an apple shoot and those from higher up is clearly seen in this experiment and is in fact a feature of numerous other trials involving cuttings from various parts of the shoot. This aspect of the work can be more conveniently discussed in a later section.

TABLE IV.

BEHAVIOUR OF PARTS OF A SHOOT OF MALLING CRAB C.
PERCENTAGE GROWN AND MEAN SHOOT GROWTH PER CUTTING.

	Apical.		Upper Middle.		Lower Middle.		Basal.	
	Grown. %	Shoot Length cm.	Grown. %	Shoot Length cm.	Grown. %	Shoot Length cm.	Grown. %	Shoot Length cm.
First Year	—	—	—	—	2·5	22	55	70
Second Year	31	55	81	70	84	105	95	280

In December, 1945, a confirmatory trial was undertaken. In this the cuttings were all from yearling shoots arising on unpruned two year parents propagated from root cuttings and from shoot cuttings. Thus the bases of the shoots used for cuttings were well above ground, unlike the basal cuttings in the first experiment.

As will be seen in Table III, the earlier result is confirmed and the root-propagated parental source is again markedly superior.

Region of Shoot Preferred.

In the winter of 1942-43 a preliminary cutting-grafting trial at East Malling revealed that a small proportion of yearling shoots of the apple rootstock Malling Crab C would, in favourable surroundings, put forth roots, and a trial was planted in March 1943 to test the rooting potentialities of different regions of such shoots. Eighty four-foot non-rooted shoots were collected from a layer bed. The bases of these shoots had been earthed to a height of three or four inches during the previous year and were etiolated. The shoots were divided into four batches of twenty, and each shoot was divided into four 12 in. cuttings. Thus there were 4 x 20 basal, lower middle, upper middle and apical cuttings and each group of four kinds was planted at random in one of the blocks in the experimental plot.

Planting in spring probably accounts for the high rate of survival of cuttings in this experiment for though few, except the etiolated basal cuttings, grew during the first season, the majority survived

TABLE V.

ESTABLISHMENT OF FOUR ROOTSTOCKS FROM CUTTINGS HAVING FOUR TYPES OF BASE.
NUMBER OF CUTTINGS GROWN (OUT OF 60 PLANTED).

	Type of Cutting.			
	Mallet heel.	Sliced heel.	Basal.	1 in. above base.
Crab C	1	3	6	nil
Brompton	3	4	6	8
Quince A	43	51	49	16
Myrobalan B ..	2	4	22	31

and grew vigorously in the second season. The figures are given in Table IV where it will be seen that whilst 55 per cent. of the etiolated basal cuttings grew in the first season only 2·5 per cent. of the lower-middle cuttings grew, and not one of the cuttings taken from the two positions higher up the shoot. At the end of the first year all the shoots on cuttings which had grown were cut down to within 1 in. of their origin. At the end of the second year those cuttings which had grown in the first year grew again, and a large proportion of the remainder made excellent growth, only in the apical cuttings was

there any appreciable loss. The second-year mean growth of the cuttings in each group forms an interesting gradient. Disregarding the basal etiolated cuttings, which form a separate class, from apex to base the figures are 55, 70, 105 cm. Thus basal cuttings were not only superior in rooting but also in shoot growth, and this in spite of the closer stand.

The superiority of basal cuttings of Malling Crab C in the experiments described in the previous section of this paper (Tables II and III) has already been mentioned. Even the values in Table III which were for cuttings collected from well above ground level, in which there was no possibility of the inclusion of any etiolated material, show an amalgamated survival value for the basal cuttings 38 per cent. greater than that of apical cuttings.

Heeled and Non-Heeled Cuttings.

When a prepared cutting contains a portion of the stem or branch from which it arose, the cutting is said to be heeled. Various sizes of heel are employed, from large portions of an older branch, which may approach half the volume of the whole cutting, through so-called mallet heels down to the thin sliver heels obtained by tearing, or slicing, the young shoot from the parent stem. Heelless cuttings are sometimes termed " straight " to distinguish them from heeled cuttings. Obviously only one heeled cutting can be made from each side shoot whereas the number of straight cuttings is limited only by the lengths of cuttings and shoots. An experimental bed of cuttings planted in 1942, containing a quince, known as Malling A, and Brompton plum, had yielded the following result. Heeled quince cuttings rooted 22 per cent. compared with only 4 per cent. for straight cuttings ; heeled Brompton 66 per cent. against 50 per cent. On a contrasting soil the figures were 28 per cent. and 5 per cent. for quince, and 30 per cent. and 31 per cent. for Brompton. Apparently the heels are important for quinces but not for the Brompton plum.

In November, 1945, a further trial was planted including two additional rootstocks, Malling Myrobalan B plum and Malling Crab C apple. The cuttings were prepared in four ways, with mallet heels, with " sliced off " heels, with no heels but including the extreme base of the shoot, and straight cuttings cut one inch above the base of the shoot. All cuttings were tipped so that they were 10 in. in length overall, and they were then planted equally deep. No growth substance treatment was given, and only a very few of the apple cuttings were established. Even so, the values tend to show that the inclusion of the base of the shoot is beneficial and the presence of a heel is no additional advantage, in fact large heels may be harmful. The values for the other subjects, presented in Table V, show that, in these, heels are no advantage in themselves but only in that they ensure the inclusion of the extreme base of the shoot and, where this aids success, as it does in quince and apple, a heeled cutting is more valuable than a straight ; though all this advantage, and more, could be retained by ensuring that the base of the shoot was present. Establishment in Myrobalan B was sufficiently good to enable it to be stated that straight cuttings of this variety are superior to heeled. The fact that large heels are prejudicial to the successful rooting of cuttings is of interest in the light of the work of Loeb (1924) who, in an exhaustive treatise on Bryophyllum, found that regeneration only occurred in detached leaves or in leaves where the flow of sap to the stem was prevented. The larger the piece of stem attached to the leaf the greater the inhibition of regeneration in the leaf.

Later observation of the heeled cuttings revealed that the roots came from the base of the yearling shoot and not from any part of the heel. This suggests that the ill effect of large heels may be due to their acting as recipients of descending substances, thus preventing accumulation of such substances in the region where the roots most commonly arise which in these cases is the base of the shoot.

Hitchcock and Zimmerman (1932) obtained similar results with greenwood cuttings and Garner and Hammond (1939), reporting on leaf-bud cutting trials, suggest that the portion of stem should be very small to ensure the best results.

Summary.

The root formation of apple stem cuttings selected from differing regions of parent plants of differing origin is related to the source of the cuttings.

1. Young parent plants propagated from roots yield more ready-rooting stem cuttings than young parents from shoots.

2. Yearling parents from roots are a better source than two-year parents. The reverse is true of one- and two-year parents propagated from shoot cuttings.

3. Cuttings from the base of yearling shoots are superior to those from the upper part, irrespective of the origin of the parent plant.

4. There is a gradient in rooting ability along a yearling shoot.

5. Heeled cuttings are only superior to straight cuttings because they ensure the inclusion of the true base of the yearling shoot. Large heels are deleterious.

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AN EXPEDITION TO FRANCE TO STUDY FRUIT TREE ROOTSTOCKS JUNE 1947

By A. BERYL BEAKBANE

As part of a plan for selecting new rootstocks for stone fruits, an expedition to France was arranged in June, 1947, to study plums, cherries and peaches both under cultivation in nurseries and plantations and as wild plants in their natural habitat.

During the first fortnight studies were made in the lower valley of the Loire between Orleans and Angers. This region includes some of the best nurseries in France as well as many fruit plantations and large areas of forest and woodland where wild species could be examined. The use of clonal rootstocks for fruit trees is not common in France, most of the trees being on seedlings. Nurserymen, growers and advisory officers were, however, greatly interested in the possibility of introducing clonal plants and were ready to help in the project of selecting new rootstocks. During the visits to fruit plantations, nurseries and schools of horticulture there were many opportunities for studying the intensive culture of fruits as espaliers, cordons and the other trained tree forms in which the French are the leading experts. These studies form the subject of a separate paper.

While the work of East Malling has resulted in the production of a range of clonal fruit tree rootstocks now used by progressive fruitgrowers in most parts of the British Isles, it has not been possible to bring rootstocks for all the different kinds of fruit to the same level of perfection and, at present, the rootstocks for apples undoubtedly offer a greater range of control over vegetative vigour and precocity of fruiting than those for stone fruits or for pears, while work on some kinds of rootstocks such as those for walnuts is only just beginning. The problem has a world-wide interest since so many of the tropical and sub-tropical crop plants are grafted onto rootstocks. In few of these crops has any kind of standardization of rootstocks yet been practicable, but it appears that, for some varieties, similar methods of selection and standardization might be applied as for our fruit tree rootstocks.

With plums, peaches and cherries, vigorous rootstocks with good, or at least moderate, qualities for ease of vegetative propagation have been selected by East Malling. Some semi-dwarfing rootstocks also exist, but these are sometimes difficult to propagate vegetatively or possess only a restricted range of compatibility. Really satisfactory dwarfing rootstocks for stone fruits are not yet in commercial use. A survey of species of wild Prunus carried out during the past few years has indicated that the qualities required for dwarfing and ease of vegetative propagation exist in the genus Prunus and has suggested the possibility of selecting new rootstocks for these fruits. A similar correlation between the internal root structure of the rootstock and its influence on the vigour and precocity of scion varieties grafted on it, has been found in stone fruits, as in apples, where the principles were first discovered. Such a correlation opens up the possibility of selecting rootstocks for these qualities on their root structure, and makes the work of selection much less laborious than it would be had each potential new rootstock to be tested by means of field trials.

Field studies in Cambridge, Worcestershire and Kent have already led to the selection of plants suitable for testing as rootstocks for the fruitgrowing industry. These studies suggested that, from a wider range of plants, growing under different ecological conditions, it would be possible to select a better range of rootstock plants to meet the needs of fruitgrowers, and it was with this end in view that an expedition was arranged to France, a country with a rich variety of Prunus plants and with a wide range of soil, climate and altitude all affecting the type of vegetation including the kinds of Prunus.

In the fertile lands through which the river Loire flows for about a hundred miles from Orleans to Angers, in north-eastern France, studies were made on many forms of stone fruit, especially St. Julien and Myrobalan. Several forms of St. Julien were noted, including one which had formed a thicket in an old clay pit and which bore a considerable resemblance to *Prunus spinosa* except that it had crenate edged leaves, and another which was growing as a tree in a garden and which much more nearly resembled *P. domestica*. The St. Julien plum is widely used as a rootstock in this area. It has some dwarfing properties and also possesses the advantage that it rarely produces suckers. No clonal races of this plum have been selected in France and it is normally raised from seed collected by the local inhabitants. The fruit, unlike the fruit of White Damas which is used for liqueurs, has no commercial value except as a source of seed for rootstock raising. Seed from plants designated the "true" St. Julien of Orleans is greatly prized and more expensive than that of other rootstocks. As a result of our expedition it has been possible to obtain a supply of this seed which will be grown at East Malling and selected for the probable effect on the vigour and precocity of scion varieties of plum and peach

grafted on it, by means of an examination of the root structure of the seedlings. The seedling stems will also be examined in order to select those which appear to be most worth testing for ease of vegetative propagation by cuttings and layers.

Although Myrobalan was not found in a truly naturalized state in France it was commonly used as a hedge plant, and in wide untrimmed hedges it often bore heavy crops of fruit. The variation in this species was very wide and much greater than had been observed in England. The variations were especially obvious in the size and shape of the leaves and fruits and in the time of ripening of the fruit. While most of the plants were vigorous, a few more dwarf and precocious individuals were observed. Myrobalan seed gathered from trees marked during our visit is being grown at East Malling.

The second fortnight was spent in the South of France where we visited the Fruit and Vine Research Station at Pont-de-la-Maye, near Bordeaux where work on plum rootstocks is in progress. Many seedlings have been raised from selected parents and by controlled cross pollination. Myrobalan seedlings, including one which appeared to be very dwarf, are undergoing layering tests. Many other seedlings from forms of *Prunus insititia* and from crosses between Marianna and Myrobalan are being tested. Since the present work of this Research Station is following lines which are closely linked with our own work on rootstocks for stone fruits, it is felt that collaboration between the two institutes would be helpful to both sets of workers and eventually to the fruitgrowing industry in both countries. No risk of reduplication, or undue overlapping, of work is likely to occur, since it is obvious that, while knowledge on methods of handling the problem can with advantage be shared, the practical research and selection should be undertaken in the climate and soil where the plants are ultimately to be used.

In the peach and cherry growing districts between Bordeaux and Toulouse one of the chief points of interest for us was a rootstock widely used for peaches and reputed to be a spontaneously occurring hybrid between peach and almond. The plants are collected from woodland areas where the hybrid is naturalized.

Studies of *Prunus spinosa* and related species and varieties indicated that the forms occurring close to the river Lot in the South of France were of a more vigorous type than the majority of forms in England, while the more dwarfing types tended to occur on the upper slopes of the river valleys. Wild and naturalized plums belonging to the species *P. spinosa*, *P. insititia* and *P. domestica* were also found on the northern slopes of the Pyrenees south of Pau. Vigorous forms of *P. spinosa* were very common in the foothills and the species occurred sporadically in the mountains up to a height of 5,000 ft.

A further report on Prunus species and varieties is planned giving measurements for per cent. root bark and descriptions of some morphological features of stem and root in plants observed in various localities including those in France.

As a result of our expedition we feel that we now know some of the best districts to visit from the point of view of rootstock studies, and we have gained experience of the kind of seed which it is most useful to collect, in addition to bringing home budwood and seed of many different types of Prunus. It was also found that studies in a different country enabled us to appreciate other aspects of the subject from those we meet at home, and gave us a fresh outlook on the problem as a whole. We hope that it will be possible to keep up the friendly contact which has been made with the research workers, fruitgrowers and others who helped in our studies in France and that we shall be able to continue these studies from time to time in the future.

Acknowledgements.

The author wishes to acknowledge with thanks the help of the other members of the expedition, Dr. R. Hill and Miss E. C. Thompson. Thanks are also due to Dr. R. G. Hatton for making the expedition possible ; to Sir John Fryer for suggesting the Loire Valley as a suitable district in which to study and to the Agricultural Research Council and the Ministry of Agriculture for providing Travelling Fellowships.

Summary.

The need for new rootstocks for fruits of the genus *Prunus* is noted, and field observations made during a collecting expedition in France are recorded.

WINTER INJURY TO APPLE SHOOTS AND SPURS IN RELATION TO PREVIOUS CROPPING

By L. B. SINGH*

The winter of 1946-47 was exceptionally severe, and caused some injury to fruit trees. This offered an opportunity to study the extent of frost damage on certain apple trees in relation to their cropping in the previous season.

Many workers have reported that the bearing of a heavy crop renders a tree more liable to subsequent winter-injury. Waring and Hilborn (1937) observed that trees of non-bearing age showed very little winter-injury in comparison with bearing trees of the same variety. Chandler (1918), Macoun (1918), Blair (1935) and others have all clearly stated that apple trees which had borne a heavy crop in the previous season were more injured by low temperature during the following winter than those which had a light crop or no crop.

Filewicz (1930) reported that even relatively resistant varieties of apple after heavy cropping had suffered more winter-injury than the less resistant ones, not carrying any crop.

Chandler (1908) found that fruit thinning of peach trees had increased their resistance to winter-injury. Macoun (1922) observed some correlation between the time of fruit maturity of different apple varieties and the amount of winter-injury ; the early maturing varieties being usually more resistant than the late ones. Anthony *et al.* (1936) observed that late picking of apples of the variety Rome accentuated frost injury to the trees. Beach and Allen (1915) found a correlation between the date of terminal bud formation and winter hardiness ; varieties that form terminal buds earlier have a longer period for the maturing process and therefore, in general, are more resistant to frost.

Blair (1935), in his survey of winter-injury, stressed the effect of meteorological conditions during the summer and autumn preceding a severe winter on the frost resistance of fruit trees ; a dry summer and wet autumn stimulate the secondary growth and delay the maturing process in the trees and thus lower their frost resistance.

Hildreth (1926) concluded that conditions such as late growth, defoliation and overbearing, generally recognized as predisposing factors to winter-injury, act by influencing the amount of reserve materials accumulated and the maturity of the trees.

Tumanov (1945) supports this view on the basis of his defoliation experiments. He puts forward, however, a new hypothesis of some activating substances related to cambial growth. According to him winter hardiness develops when part of these substances becomes inactivated and the remainder descends into the root system. Ringing of trunks or branches interferes with this movement and in consequence the part of the tree above the ring does not acquire winter hardiness and is killed even by moderate frost.

Material and Method.

The material recorded in the present study included three varieties of apples, namely, Early Victoria, Miller's Seedling and Cox's Orange Pippin, having different times of fruit ripening, i.e. late summer, early autumn and winter respectively. Twenty-five extension shoots from each of two " on " and two " off " year trees of each variety, with the exception of Cox's Orange Pippin, were collected at random in the field on 11th and 14th February, 1947 and examined in the laboratory. Of Cox's Orange Pippin, many comparable trees were available, and extension shoots were collected from a larger number of trees, 38 in the " on " and 9 in the " off " phase. The trees were on seedling stocks and grown as bush trees. After the length had been measured, each shoot was slit longitudinally for examination. In many shoots a browning of the pith from the tip downwards, a typical symptom of mild winter-injury, was found. The length showing browning was measured, and expressed as a percentage of the total length. Similarly, 25 spurs from 2 " on " and 2 " off " year trees of Miller's Seedling apple were collected and slit down the middle. Dards and bourses were examined separately and the damage was recorded in four arbitrary categories (from 0 to 3) expressing the degree of discoloration of the pith. Category " 0 " was given when no discoloration could be seen and " 1 " when the discoloration was very slight, while categories " 2 " and " 3 " denoted dark or very dark discoloration respectively. As there was very little difference in colour between the categories " 0 " and " 1 ", they were summarized together as undamaged. Similarly categories " 2 " and " 3 " were

* Extracted, with modifications, from a thesis approved by the University of London for the Ph.D. degree.

also taken together, both indicating severe damage to the pith. Thus, the percentage of dards and bourses damaged was calculated from the number in categories " 2 " and " 3 " in relation to the total number examined.

Climatic Conditions.

The summer and autumn of 1946 were abnormal in both rainfall and sunshine. The rainfall in June and July was near the average, but the rainfall in August was 5·03 in., compared with a thirty year average of 2·20 in. September was also rather wetter than usual. The late summer and autumn months also had abnormally little sunshine. The dry weather in July followed by a very wet August stimulated secondary growth and delayed the ripening of wood, thus predisposing the trees to winter-injury.

The winter in 1946-47 was also unusual ; there was an unbroken period of frosty nights extending from the middle of January to the beginning of March, and the minimum screen temperature fell as low as 0° F. on two successive nights, 29th and 30th January, and to 1° F on 24th February as shown in Fig. 1.

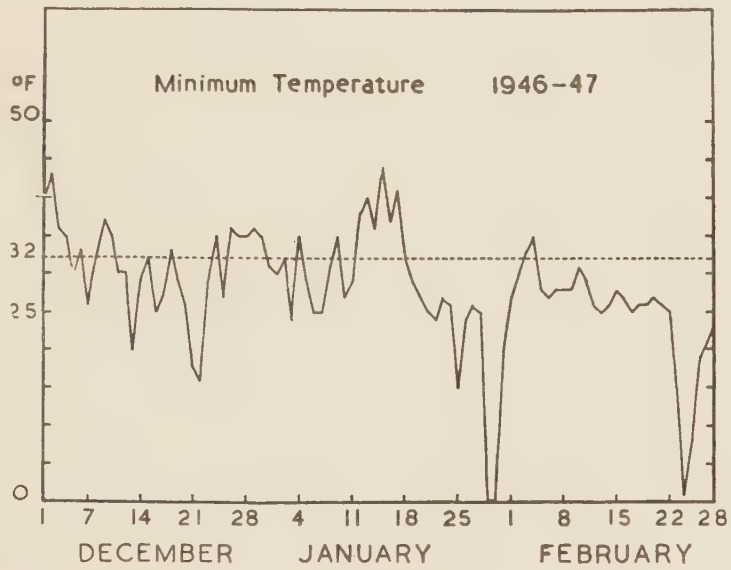

Fig. 1.

Minimum air temperature in the screen at East Malling (height 4 ft. 6in.).

Thus, trees, although predisposed to winter-injury by late growth and lack of wood maturity, had time to acquire some hardiness as the low temperature did not occur until the end of January. In consequence the damage observed, as described later, was light, but distinct enough to show a clear difference between trees having high or low crops in the previous year.

Results.

In the case of shoots the injury was confined to the pith only and expressed in its discoloration, ranging from light to dark brown. It was more marked at the less mature tip of the shoot and lessened in intensity towards the base, as shown in Fig. 2(*c*). It was noted that the pith opposite the buds was usually distinctly more discoloured than that lying in the internodal region of the shoot, and it therefore appears that the region opposite the buds is relatively more tender. Secondary growths were more damaged than primary ones, especially at their junction with a primary shoot.

Table I shows that, in contrast with the observations reviewed above, the extension shoots of the three varieties investigated were much more damaged on the trees which had no crop in the previous year than those on the trees which had cropped heavily.

The differences ranged from about twice to about five times as much damage, following the " off " year, as following the " on " year, and all are statistically significant ; the most severe damage was on Miller's Seedling. The data also show that Miller's Seedling, one of the early maturing varieties, is

more injured than the relatively late maturing Cox's Orange Pippin. The damage to typical shoots of Miller's Seedling, following their " on " and " off " year phases, is shown in Fig. 2, (*a*) and (*b*), respectively.

Damage to spurs, however, showed that dards from " on " and " off " year trees did not differ significantly in the amount of winter-injury (Table II) ; and bourses were more damaged on the trees in the " on " year than on the trees in the " off " year. On the whole, bourses were more damaged than the dards, both in " on " as well as in " off " years.

TABLE I.

WINTER INJURY TO EXTENSION GROWTH OF THREE APPLE VARIETIES FOLLOWING THEIR " ON " AND " OFF " YEAR PHASE.

Variety.	Time of picking of fruit.	% length showing winter injury. Following " on " year	Following " off " year.	Significance P=0·05
Early Victoria	July-August	5·6	30·2	Significant
Miller's Seedling	End of August	42·2	95·2	Significant
Cox's Orange	October	34·0	67·1	Significant

A number of shoots of Cox's Orange Pippin were examined to find the relationship between the length and thickness of these shoots and the amount of winter-injury. The shorter and thicker shoots were more damaged than longer and thinner ones. Statistical analysis of the results showed that an increase of 1 cm. in length corresponded with a decrease of percentage damage by 0·89 per cent. for " on " year trees and by 1·48 per cent. for " off " year trees ; whereas an increase of 1 mm. in diameter corresponded with an increase of damage by 14·1 per cent. for " on " year trees and 8·4 per cent. for " off " year trees.

Discussion.

At first sight the effects of cropping on the frost resistance of shoots, shown in Table I, seem to oppose the view generally held that heavy cropping predisposes the tree to frost injury. However, this is not the case, for this investigation refers not to the whole tree, but to certain parts of it, i.e. extension shoots, bourses and dards. The temperature was not low enough to damage the whole

TABLE II.

WINTER INJURY TO THE SPURS OF MILLER'S SEEDLING FOLLOWING THEIR " ON " AND " OFF " YEAR.

	Percentage of spurs showing distinct or severe damage. Following " on " year.	Following " off " year.	Significance P=0·05.
Dards	28%	34%	Insignificant
Bourses	86%	46%	Significant

tree, or the trunks or lower branches, as is usual where winter-injury is severe ; but the present study fits in with the conclusions of previous workers and extends the available information in relation to shoots and spurs.

The fact that extension shoots from " on " year trees were less injured than those from " off " year ones was probably due to the rate and time of their development. The shoots from " on " year trees started growing and developed rapidly earlier in the season, so that they had a longer period for maturing than the shoots from " off " year trees, which started growing later, and developed at a

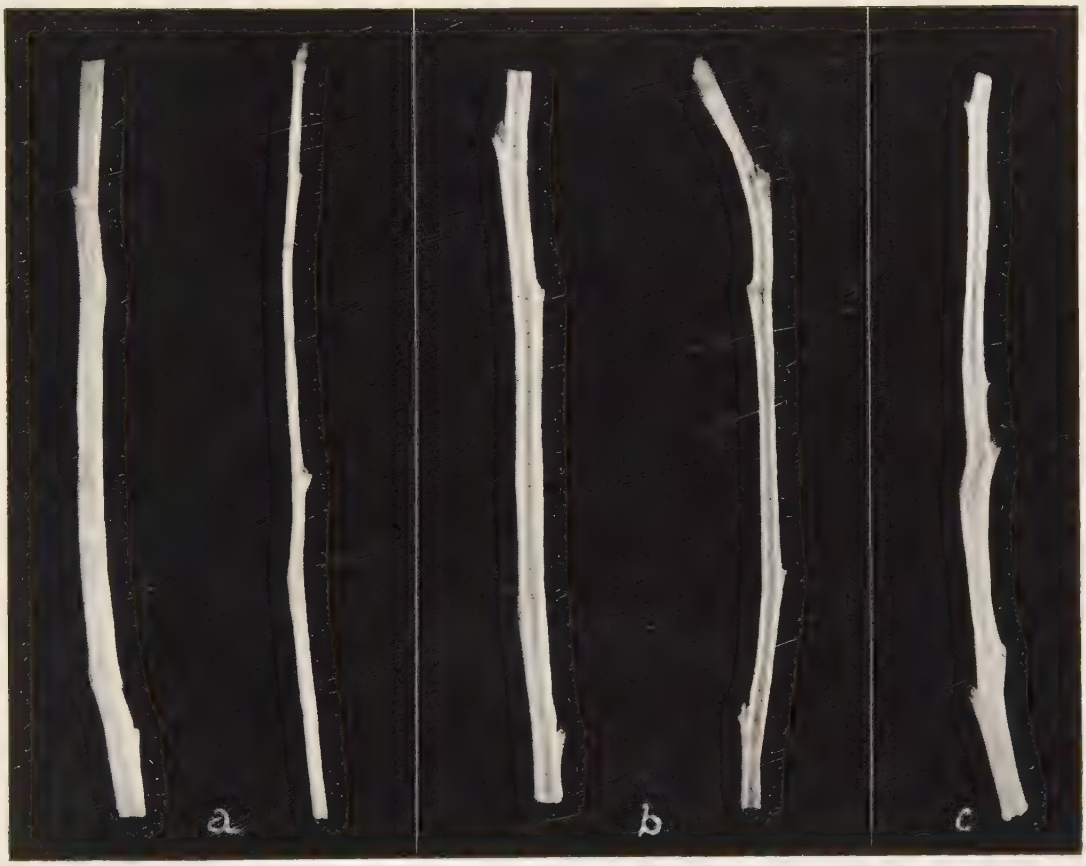

Fig. 2.

Miller's Seedling shoots.

(*a*) from "on" year tree showing little or no discoloration of pith.
(*b*) from "off" year tree, showing much discoloration of pith.
(*c*) showing greater discoloration at the tip than at the relatively more mature base.

face p. 80

a *b*

FIG. 3.

Miller's Seedling—photographed on 29th October, 1946.
(*a*) Showing defoliation of extension shoots in " off " year trees.
(*b*) Showing defoliation of extension shoots in " on " year trees.

slower rate until the beginning of the second period of shoot growth (Singh, 1948). Thus, the " off " year shoots had relatively less time for ripening of their wood.

This point is further strengthened by observations of the time of defoliation, which showed that " off " year trees retained their leaves on extension shoots for more than a week longer than " on " year trees. Fig. 3 illustrates this point.

The damage to spurs (bourses) was as expected from previous work, i.e. higher on those which had fruited during the previous summer than on those which had not. The bearing of fruit had presumably weakened their frost resistance considerably by using up their carbohydrate reserves. In fact, the fruiting spurs were left in a relatively more nitrogenous and immature condition, as a high proportion of the carbohydrates manufactured by them was used up by developing fruits (Singh, 1948).

The effect of manuring (NPK) and of pruning (spur against renewal pruning) upon resistance of shoots to frost damage was also investigated, but under East Malling conditions in 1946-47 no significant differences were found between these treatments. The effect of cropping, however, was always clear.

The results described above were confirmed for Miller's Seedling in 1948. As in the previous year twenty-five shoots from each of two " on " and two " off " year trees were examined in March, 1948. Following an " off " year, 70·9 per cent. of the length of terminal shoot and 33·2 per cent. of the length of laterals showed winter-injury, while no damage at all was found in the shoots collected from trees which had borne a crop in the previous year. All these differences are highly significant.

Acknowledgements.

The author acknowledges with thanks much help from Dr. Irena Modlibowska in carrying out this study. The confirmatory work in 1948 was done by Miss F. Bacon, to whom the author extends his thanks.

Summary.

Frost injury to apple shoots and spurs in winter 1946-47 was investigated in relation to cropping of trees.

Shoots from trees in the " off " year were more injured than those from trees in the " on " year.

Frost injury to shoots was found to be negatively correlated with their length and positively with their diameter.

Spurs reacted to frost differently from shoots. Bourses were more injured on the " on " than on the " off " year trees, while between dards in " on " and " off " year trees no significant difference was found.

The results are discussed in relation to time of defoliation and degree of maturity of shoots and spurs.

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A TEST OF NITROGEN, PHOSPHORUS AND POTASSIUM INJECTIONS IN BIENNIAL BEARING APPLE TREES

By L. B. SINGH*

Many investigators have suggested that biennial bearing results from the excessive drain of a heavy crop on reserves of nutrients (Singh, 1948). This note describes an experiment to test whether the injection of major nutrients into " on " and " off " year trees would affect their biennial habit.

Nutrient substances were injected in the " on " year in the hope of making good any deficiency of those substances and so enabling fruiting spurs not only to carry a crop during that season but also to lay down fruit buds for the following year thus ensuring the regularity of cropping. On the other hand, nutrient substances were injected into the branches of " off " year trees with the object of stimulating their growth so that a considerable percentage of spurs which would normally produce fruit buds in that season might be forced into vegetative growths and thus two sets of spurs might be produced bearing fruits in alternate years.

Sen (1936) injected branches from " on " and " off " year trees of Bramley's Seedling with solutions of various nutrient substances and got definite responses in growth. He reported that urea gave a big increase in the shoot growth in the " off " year whereas urea with potassium salts gave a small increase in shoot growth both in the " on " and in the " off " year. No conclusions relating to the problem of alternate cropping can be drawn from this study, however, because no count of fruit buds was taken. The object of the present experiment was not only to study the effect of nutrient injection on shoot growth produced but also the effect on number of fruit buds formed.

Experimental Material.

Six 30-year-old Miller's Seedling apple trees in biennial bearing condition (three in their " on " and three in their " off " year phase) were used for the experiment. On each of these six trees, sixteen " experimental branch " units consisting of the terminal parts of the branches or sub-branches, each one metre in length and of comparable diameter at the base, were chosen. These were further grouped in sets of eight thus providing two sets of eight " experimental branches " on each of the six trees.

Experimental Procedure.

It was decided as a first step to test all combinations of nitrogen, phosphorus and potassium.

Since it was not known at what stage of bud development injections would have most effect on fruit bud differentiation, it was decided to make injections at two different times during the expected crucial period of fruit bud formation and shoot growth extension. The first set of injections was done on 20th June, 1946, when the vegetative clusters had formed a fully open rosette, with a bud beginning to form in the centre, and the next one, 3 weeks later on 15th July. The two sets of comparable branches chosen on each tree provided for one early and one late injection of each nutrient treatment on the same tree, the material available giving a total of twelve replicates of each nutrient treatment. The treatments were allotted to the branches at random. The amount of total salt to be given to each branch was injected at the rate of 0·5 gm. of total salt per square cm. cross sectional area. The liquid injected contained 0·5 per cent. of each salt. The same concentration had been used with advantage and without any toxic effect by Sen (1936). Since the girth of each branch was approximately 8 cm., each one was injected with 250 c.c. of one of the following solutions :—

Salts.	*Treatment.*
Urea, $CO(NH_2)_2$ (0·5 per cent.)	N
Disodium hydrogen phosphate, Na_2HPO_4 (0·5 per cent.)	P
Potassium sulphate, K_2SO_4 (0·5 per cent.)	K
Urea (0·5 per cent.) + disodium hydrogen phosphate (0·5 per cent.)	NP
Potassium nitrate, KNO_3 (0·5 per cent.)	NK
Dipotassium hydrogen phosphate, K_2HPO_4 (0·5 per cent.)	PK
Urea (0·5 per cent.) + dipotassium hydrogen phosphate (0·5 per cent.)	NPK
Distilled water	W

The injections were carried out by the liquid branch-injection method described by Roach (1937). The injection liquid was held in a carton placed above the point of injection and the liquid, under a small head, passed through a rubber tube to the injection hole. The liquid was absorbed in from 24 to 36 hours.

* Extracted, with modifications, from a thesis approved by the University of London for the Ph.D. degree.

TABLE I.

EFFECT OF INJECTION OF NUTRIENT SUBSTANCES ON (*a*) SHOOT GROWTH IN THE CURRENT YEAR. (*b*) FRUIT BUD DIFFERENTIATION AND (*c*) CROP IN THE FOLLOWING YEAR.

Nutrient.	N.	P.	K.	NK.	NP.	PK.	NPK.	Water.
(*a*) Shoot growth in current year (cm. per branch) :								
"Off" year trees	169	161	140	146	143	129	156	152
"On" year trees	116	144	123	133	125	122	119	120
(*b*) Fruit buds recorded in spring following injection (mean no. per branch) :								
"Off" year trees	428	419	404	425	422	440	401	422
"On" year trees	5	3	3	4	5	7	4	6
(*c*) Crop weight, year following injection (mean weight per branch) :								
"Off" year trees	33·8	34·8	33·0	34·7	27·9	33·2	28·2	41·8
"On" year trees	0·6	0·3	0·5	1·1	0·6	0·8	0·3	0·6

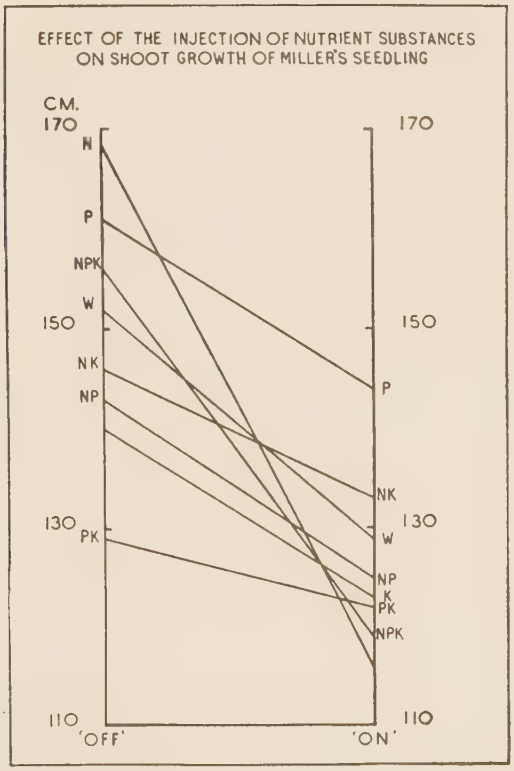

FIG. 1.

Effect of injection of nutrient substances, into branches of "on" and "off" year trees, on current year's shoot growth.

Results.

The effects of the various treatments on shoot growth, fruit bud formation and crop are summarized in Table I. As no consistent differences appeared between the results for the two different times of injection, they are averaged and each figure is thus the average of twelve treated branches. It is seen (*a*) that the " on " year trees had slightly less growth than the " off " year ones, but none of the nutrient injections gave any important difference from the control branches ; (*b*) in fruit buds, as recorded the following spring, the trees which were injected in " off " year condition all had about equal amounts of fruit buds, irrespective of the injection treatments ; and those injected in the " on " year all reverted to typical " off " year condition, having practically no fruit buds. Again no contrasts were provided by the injections ; (*c*) the crop weights were on similar lines to the fruit bud counts.

Thus these results do not suggest that a deficiency of any of the three major nutrient elements, or of any combination of them, is responsible for biennial bearing.

One curious fact is worth mention, although there is no obvious explanation of it. The grand totals of shoot growth are set out graphically in Fig. 1 for both the " on " and " off " year trees. As already mentioned, there was more growth in the " off " year than in the " on " but there was a remarkable parallelism between the two sets of results, with the exception of two. These are the ones for N (urea) and NPK (urea plus dipotassium hydrogen phosphate). N came highest in the " off " year and lowest in the " on " and NPK came third highest in the " off " year and second lowest in the " on " year. The orderliness of the majority of the shoot growth results are in marked contrast with the bud count results set out in Table I.

Conclusion.

The results do not suggest any serious deficiency of any of the three major elements. While this work was proceeding, another worker tested for other deficiencies by diagnostic leaf injections and obtained some suggestion of iron deficiency . This indication would appear to be worth following up by an experiment of the same type as the one just described.

Acknowledgements.

The writer acknowledges with thanks the help and advice of Dr. W. A. Roach in prescribing the treatments, and of Dr. Roach and Dr. W. S. Rogers in preparing this paper for publication.

Summary.

Injection of the three major elements, N, P and K, alone and in combination, into branches of Miller's Seedling, both in " on " and " off " year phases, did not affect their subsequent biennial behaviour ; this suggests that it was not lack of any of these elements which was responsible for biennial bearing of these particular trees.

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WEATHER CONDITIONS DURING 1947

By A. P. PRESTON

The year 1947 has been an exceptional one for weather at East Malling. Few months have passed without breaking some previous record set up since our observations began in August, 1914. The very cold weather during January and February, when zero screen temperatures were recorded and the ground was snow-covered continuously for seven weeks, was followed by the wettest March ever recorded here with a rainfall of 4·97 inches. It was during the second week in April when land cultivation began and the very sunny weather during that month, averaging 6·6 hours a day, helped dry the soil and make good the loss of work during the previous three months.

Rainfall during the year amounted to 23·72 inches, 2·52 inches below the 30 years' average for this Station, and it is interesting to note that the year's rainfall at the end of September was 1·87 inches above the 30 years' average due to the heavy falls in March, May, June and July, but the exceptionally dry October brought the total rainfall below the average. November was also a comparatively dry month, while the December rainfall was just above the average. Periods of severe drought were recorded during the summer and much of the rain which fell during June, July and September was too heavy to be beneficial and flooding and soil erosion were noted in this district. A notable fall was on 27th June when 0·96 inches fell within 15 minutes during a severe thunderstorm. August was the driest month ever recorded here and the period of drought from the latter part of July until the middle of September comprised 58 days without rain beneficial to the agriculturist. The driest October was also recorded here this year with a rainfall of 0·39 inches.

Sunshine during the year amounted to 1724·2 hours, 246·3 hours more than the 30 years' average. Only February, March and December had sunshine below the average, all the other months had sunshine well above the average. During February sunshine was recorded on only seven days, while August with 280·7 hours of sunshine was a record for this month at East Malling.

Apart from January and February, temperatures have been generally above the average this year, and some high temperatures were recorded in the screen during June and July. The monthly mean maximum screen temperatures from May to October inclusive were well above 60° F. Thunderstorms occurred frequently during May, June, July and September and they were often accompanied by very heavy rainfall. Late spring frosts were absent again this year and from the last week in April ground frosts were not recorded until October. Good crops of hard and soft fruits were harvested, but slight hail damage was noted upon the softer apple varieties after a severe thunderstorm in July. September and October were unusually free from autumnal gales, very calm weather was recorded during the first three weeks of October, which considerably assisted the picking of the late apple varieties.

Acknowledgement.

The writer wishes to acknowledge with thanks the assistance he has received during the year from Miss J. M. S. Thom in computing the data and in preparing the diagram (see p. 87) for publication.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1947.

Month.	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	30 years' average.	Total Hours.	Average per day.	30 years' Average.	4 inches.	8 inches.	2 feet.
January	40	28	53	0	34	22	2·17	0·30	2·53	54·3	1·8	45·8	34·6	35·7	38·6
February	33	25	40	1	29	27	1·35	0·41	1·82	28·6	1·0	67·3	31·6	32·7	35·3
March ..	46	33	58	14	39	14	4·97	0·78	1·52	68·9	2·2	118·7	37·9	37·2	39·0
April ..	58	40	71	27	49	6	1·54	0·46	1·99	199·1	6·6	131·7	49·6	46·4	47·2
May ..	67	46	85	35	56	0	2·06	0·79	1·77	214·5	6·9	198·3	59·4	55·3	55·1
June ..	70	50	90	41	60	0	2·17	0·99	1·44	247·2	8·2	204·0	66·8	62·9	63·1
July ..	74	55	89	45	64	0	3·69	1·52	2·20	219·1	7·1	190·7	67·6	65·5	65·7
August ..	76	55	86	44	65	0	0·01	0·01	2·27	280·7	9·1	181·9	69·4	67·3	69·1
September	70	49	82	36	59	0	1·53	0·91	2·08	182·4	6·1	145·8	61·3	60·5	64·0
October	61	40	72	25	50	5	0·39	0·38	2·82	131·4	4·2	100·9	50·1	50·4	55·1
November	51	38	62	23	44	11	0·91	0·37	3·15	65·9	2·2	53·7	43·6	44·3	47·9
December	47	37	55	19	42	11	2·93	0·75	2·65	32·1	1·0	39·1	40·0	40·6	42·8
Totals						96	23·72		26·24	1724·2		1477·9			

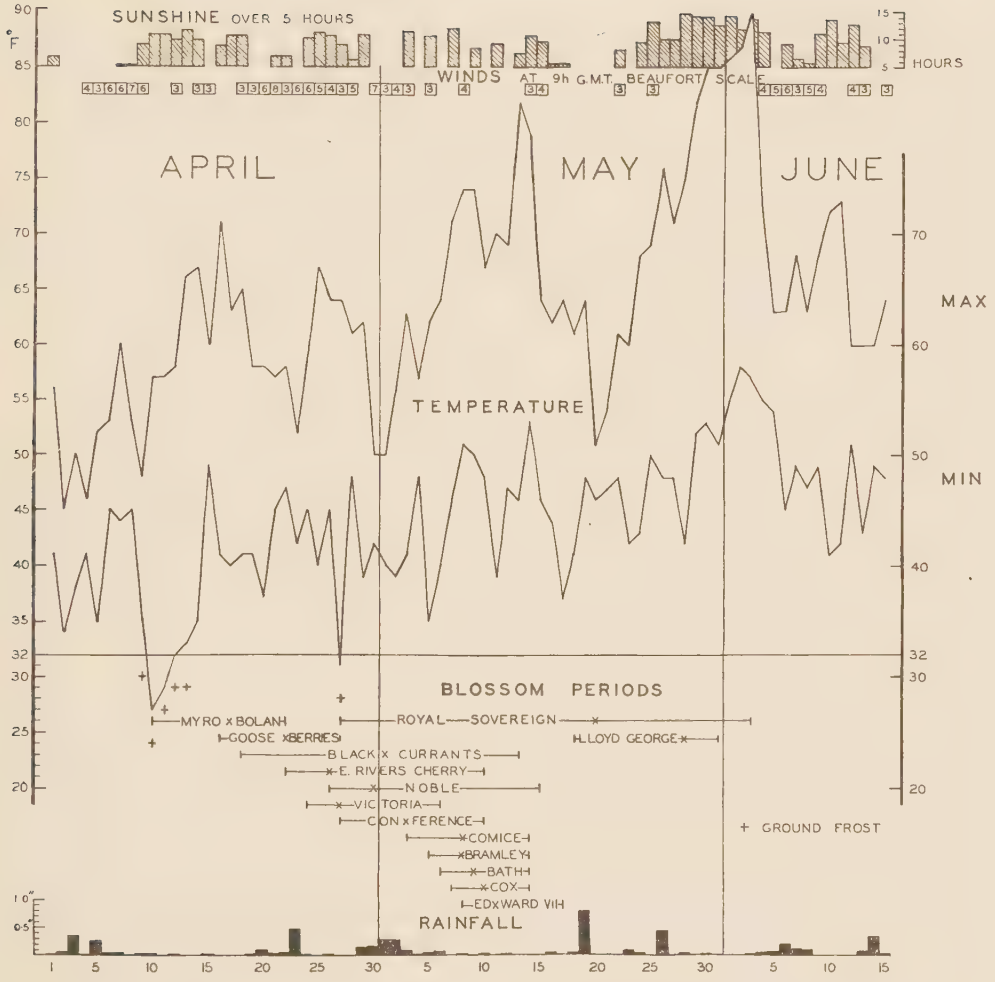


Diagram to show the weather recorded during the Blossoming Season, 1947.

STATISTICS

A REVIEW OF EXPERIMENTAL DESIGN AT EAST MALLING, 1919-1947

By S. C. PEARCE and T. N. HOBLYN

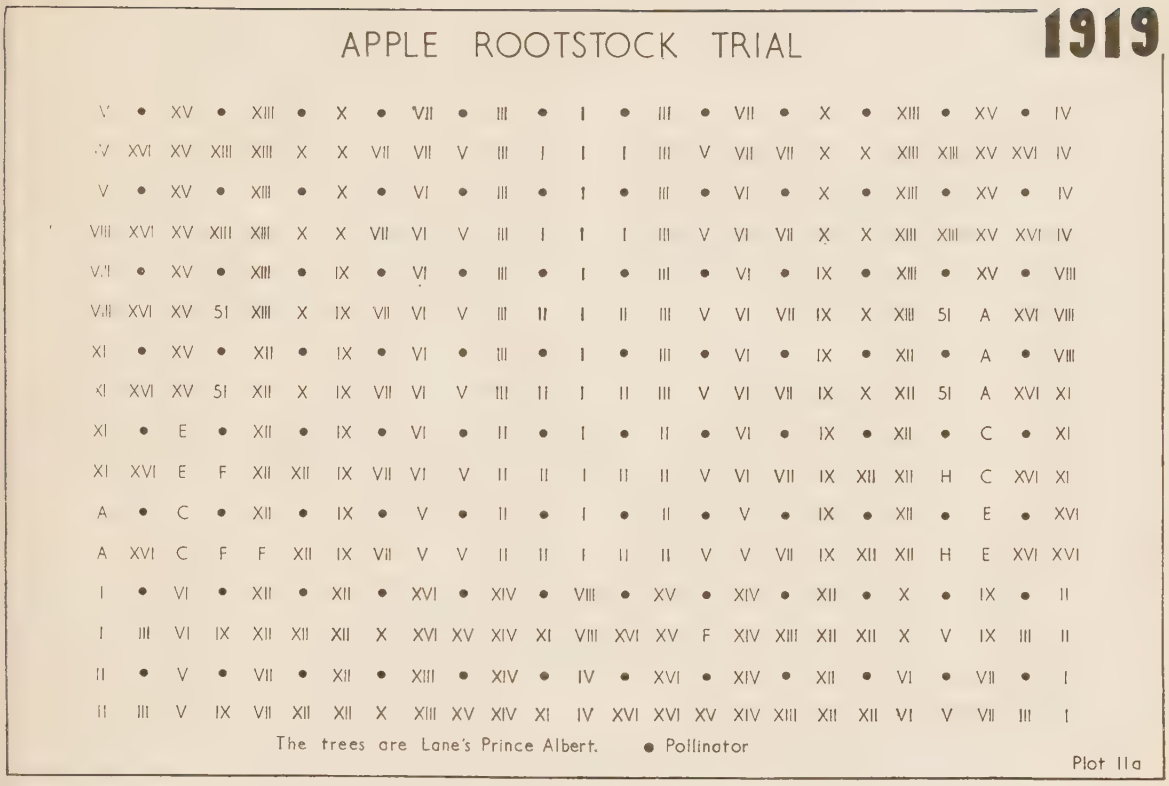
The thirty-four years since the founding of the East Malling Research Station have seen the rise of the greater part of modern statistical theory. In no other subject of concern to the research worker in horticulture have such revolutions taken place both in fundamental conceptions and in the details of technique. In the circumstances, it is of interest to review the past, recalling some of its more important trials and appending the conclusions arrived at as a result of this experience.

General Review.

A glance through the diagrams of this paper will show that there have been continual changes in the designs favoured. Thus, neither of the 1934 trials could possibly have been planned in either 1924 or 1944. Indeed, they could hardly belong to 1932 or 1937, so rapidly have ideas developed. There have been two big changes as well as innumerable smaller ones. First, from systematic designs to randomized ones and, secondly, from simplicity to complication. With both, the same tendencies may be observed, namely, a violent swing to the new conception followed by a gradual realization that the old was not wholly bad. Nowadays, the old simplicity is ranked very high among the desiderata of a good trial, but the new randomization has without question won its place, at least, where " significant differences " are called for.

The earliest designs were simple and " balanced ", i.e. laid out to minimize the effect of soil variation. The introduction of randomization brought into use lay-outs such as the Latin Square, though for some time there was no whole-hearted acceptance of the complete randomization logically implicit in them. Next, simplicity gave way to the complexity of factorial designs. It was, of course, reasonable to include together as many factors* as possible since only thus can reliable information be obtained about interactions. The practical difficulties of managing such trials in the field were not, however, foreseen and in these days complexity is avoided whenever possible. The simplicity of a good modern trial is, however, deceptive. Formerly, experiments were simple because designers believed firmly that only one factor should be altered at a time. Nowadays, there are two reasons. First, unfortunate experiences with complex trials have led to a desire to avoid unnecessary hazards. Secondly, it is thought better to start simply and to add other factors later if this appears both desirable and practicable. The aim is *flexibility*—trees are lost, the plantation has to be thinned, new questions are asked and old ones answered and so on—and it is necessary very carefully to consider the future.

* It would perhaps be helpful to define some of the terms that will be used. Suppose two methods of pruning are combined with three manurial programmes to give six *treatments*, then pruning and manuring are spoken of as *factors*. The results will be considered under the heads of two *main effects* (i.e. (1) the differences arising from the two pruning methods, the results of each having been averaged for the three manurial treatments and (2) the differences arising from the three manurial treatments, the results of each having been averaged for the two pruning treatments) and an *interaction* (i.e. the extent to which the differences due to the manurial treatments are altered by the pruning methods. This is, equally, the extent to which the differences due to the pruning methods are altered by the manurial treatments). In a body of data certain comparisons are possible between figures and groups of figures, but not all will be independent of one another. The number of independent comparisons is called the *total degrees of freedom*, which is thus a measure of the amount of information yielded by the data. Certain of these independent comparisons will be unrelated to any of the main effects or interactions being considered or to the blocks etc. in which the experiment is laid out. The number of such comparisons is referred to as the *error degrees of freedom*, this being a measure of the information yielded about the extent of those sources of variation not specifically considered by the trial, i.e. " error ".



Apple Rootstock Trial, 1919.

This is a good example of the "balanced" type of experiment, i.e. one in which the treatments are disposed so as to equalize the effect of trends rather than to measure the variation introduced by them. Thus, stock M.I. in this trial is mostly to be found in the middle row, but two trees in the first row are *balanced* by two others on the opposite headland and so it is as far as possible with the other rootstocks. The intention was to reduce experimental error to a minimum but there is no measure of the residuum. Though systematic trials are no longer used for the comparison of treatments, they have come back into vogue for other purposes. The first stage of an investigation often calls for a visual survey of the possible effects of the treatments and this cannot easily be made if the experiment is randomized. Again, an experiment to be complete needs a demonstration plot. For either of these purposes nothing can beat a simple but balanced design with the treatments disposed in rows cut across by a landway. Only for the intermediate, though highly important, stage when the differences associated with treatments are being compared with those that could have arisen by chance is randomization desirable, and there it is essential.

Another feature of this trial is the wide range of vigour represented by the rootstocks. In 1919 this was inevitable because no one knew how the various stocks would behave. Nowadays, however, work on the histological structure of roots enables new rootstocks to be roughly classified before they are ever compared in a field trial and the problem is to find the best in each vigour group. This has led to important modifications in the technique of rootstock trials.

Apple Manurial Trial, 1930.

The invention of the analysis of variance in 1923 brought in the randomized trial of which this is an excellent example. It has eight blocks each of eight plots, one for each of the treatments obtained from nitrogen (N), phosphate (P) and potash (K). This choice of treatments was in line with Professor Fisher's dictum that Nature replies better to a questionnaire than to a question, providing, as it did, for the investigation of seven effects, four interactions N and P, N and K, P and K, and also N, P and K, as well as the three main effects, viz. those of N, P and K. It seems now that this scheme has also one of the disadvantages of a questionnaire in being rather inflexible. Thus, no effect of phosphate has been observed at any time, while the effect of potash has become so large that the trees having potash have often had to be considered separately from those without it ; yet it was completely contrary to the conception of such a trial to change treatments during the course of an experiment. It is now known that the changing of treatments in a trial like this can easily be carried out without loss of validity. After all, an apple plantation should last for several decades and will almost certainly outlast the questions it was originally designed to investigate.

Since it is not economic to guard small areas, each plot contains 25 trees, of which nine in the middle are experimental and represent seven stock/scion combinations. By first removing the trees on M.IX and then those on M.I. and M.V it was intended to thin the plantation without invalidating the design. This placing of the stock/scion combinations on the plots of the manurial trial is an interesting anticipation of the split-plot design, differing from it only in the systematic lay-out within the manurial plots.

In practice, this trial has sometimes suffered from the extremely low feeding of some of its trees. Thus, the plots without potash became so poor that a basic dressing had to be applied. Again, the guard trees being fertilized on only one side (or on only one quadrant with the corner trees) it became necessary to extend the manured area to the middle of the guard alley, thereby losing much of the advantage of having double guard rows. In designing a manurial trial care should always be taken that even the least fertilized trees have a chance to grow normally.

The large blocks of this trial have made it rather harder than usual to show significant differences because of the high variability. Small blocks are always desirable.

If this trial were being designed to-day, more use would have been made of injection techniques to find out what the trees needed. Generally, a fertilization problem poses three questions :

(1) What elements do the trees need ? The biochemists can usually answer this without a field trial.

(2) How can a needed element be best applied ? This can be answered only by a field trial.

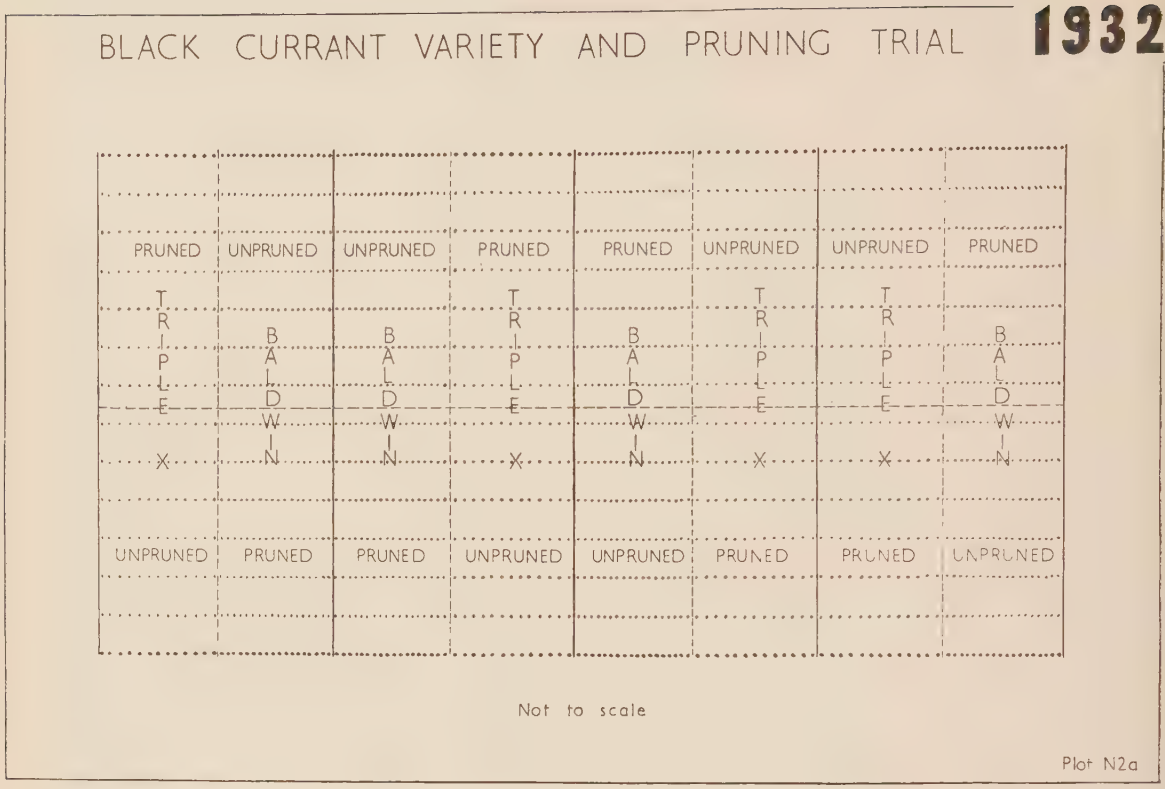
(3) How much should be applied ? This also calls for a field trial, though ideally not the same one as for the second question. The chief criticism to be made of this experiment is that it used a field trial in order to answer the first question. This criticism is perhaps a little unjust, because it was also a purpose of the trial to observe the effects of presence and absence of the three elements singly and in combination. In the main, the conception was excellent, specially in the rigorous use of all the eight treatments possible with the given factors. Even to-day trials are sometimes vitiated by leaving out a treatment that should logically be included.

APPLE MANURIAL TRIAL 1930

N	NPK	P	PK	K	P
O	NP	N	K	PK	N
PK	P	NP	NK	NK	NPK
NK	K	O	NPK	NP	O
O	PK	NPK	K	P	NP
P	K	NP	PK	NPK	K
NP	N	O	N	N	NK
NK	NPK	NK	P	PK	O
NK	PK	P	K		
N	NPK	NP	O		
PK	NPK	O	N		
K	NP	P	NK		

W	D	W	D	W
D	C I	B IX	B I	D
W	C IX	C XII	C IX	W
D	B V	B IX	C V	D
W	D	W	D	W

Plot C2 cd

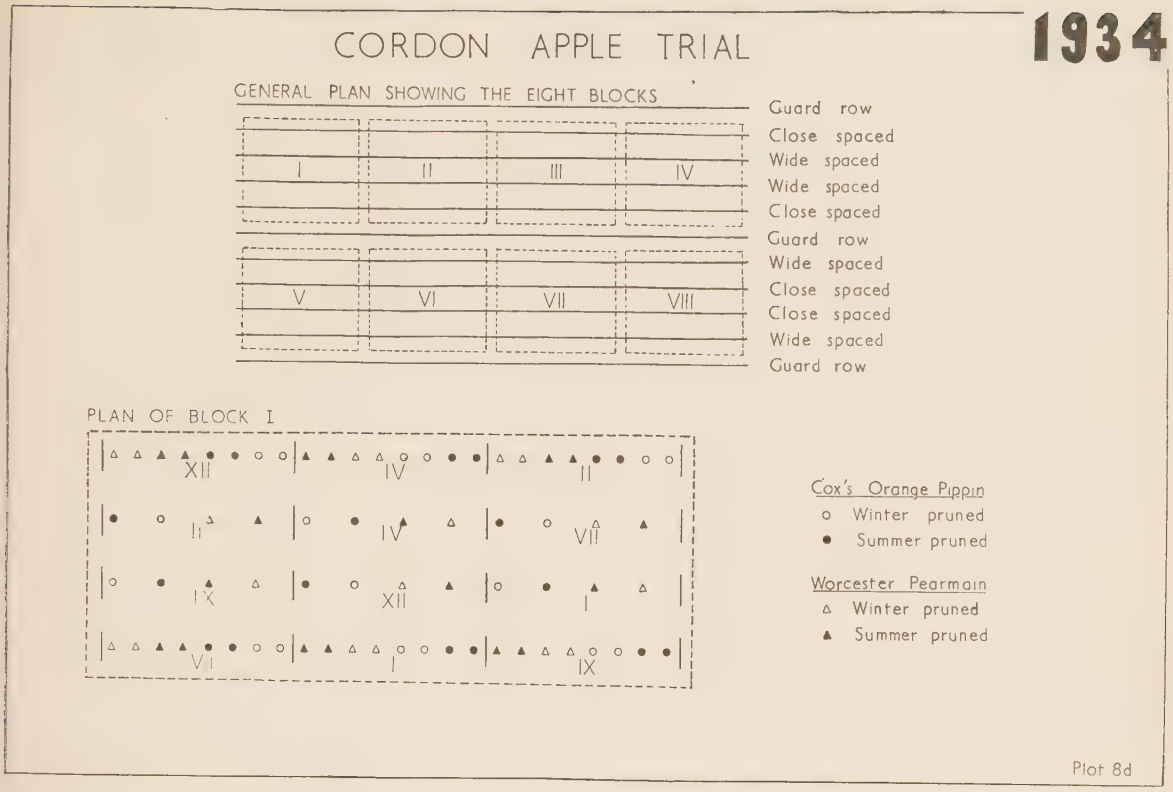


Variety and Pruning Trial, Black Currants, 1932.

This was one of the first split-plot designs. It had four blocks each containing a plot of Triple X and a plot of Baldwin, then each of these plots was divided into a sub-plot of pruned bushes and one of unpruned. In fact, the plots of the variety trial were used as blocks of the pruning trial. The advantages of such design will appear in the two experiments that follow and will explain why split-plots are now the commonest of all designs at East Malling.

This trial was not completely randomized, the treatments of both factors being " sandwiched ", i.e. arranged ABBA. This was done to diminish as far as possible the effect of soil variation on treatment differences. This practice is now seen to be undesirable, because, in the process of the analysis of variance, any variation artificially removed from the treatment effect in this way is ascribed to error. Since the significance of the treatment effects is judged by examining the excess of treatment variation over error variation, the effect of sandwiching is to disguise significance. In general, no restriction should be applied to the randomization that cannot be allowed for in analysing the results.

It will be seen that the two varieties were spaced differently. This does not matter so long as the trial is concerned only with crop per acre, a quantity that, indeed, cannot be judged unless each variety is being grown at the optimum distance that would be used in commercial practice.



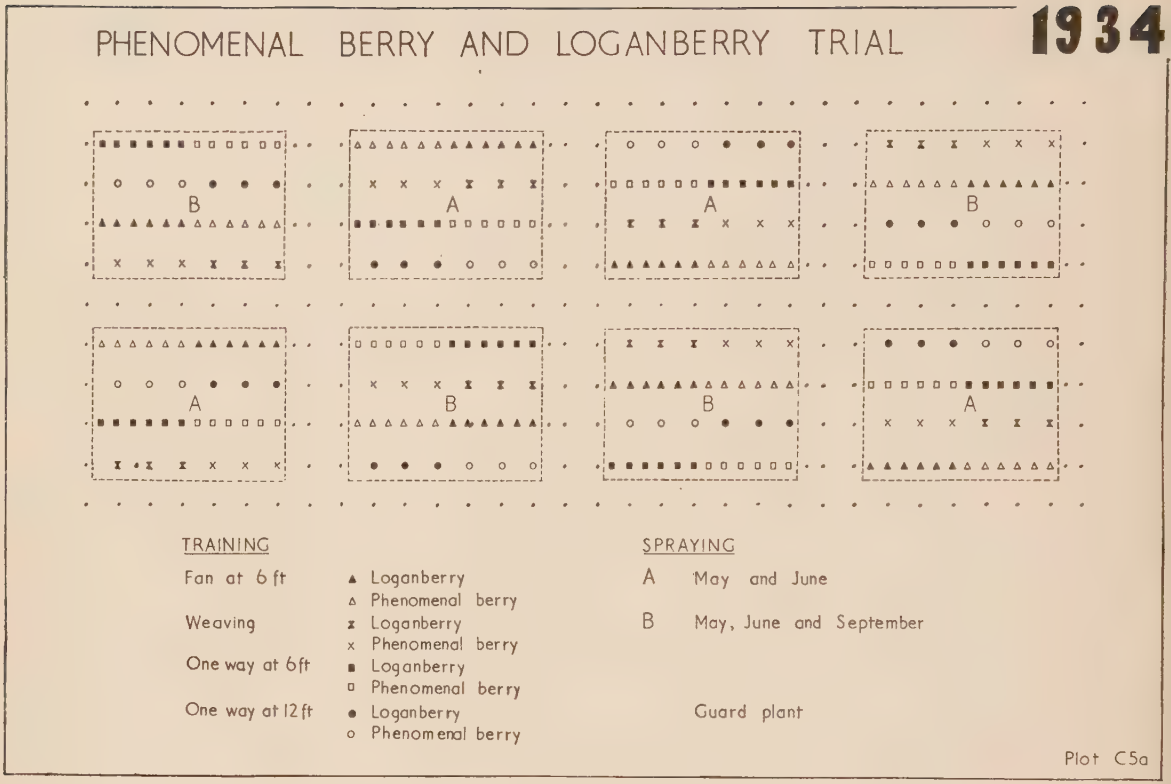
Cordon Apple Trial, 1934.

This extremely complex split-plot design well repays study, the details being ingenious. The first treatment is spacing and each block is made up of four quarter-rows chosen to dispose the spacing treatments in sandwiches. These treatments extend over whole rows, so the eight blocks fall into two groups, the arrangement of the spacing treatments running through all the blocks of a group. Each main plot is divided into six sub-plots on which six rootstocks are disposed at random. Each sub-plot has two sub^2-plots for the varieties, which are arranged alternately up the rows but in sandwiches across them. Each sub^2-plot contains two sub^3-plots for pruning treatments which are arranged in sandwiches within each sub-plot, the form of the sandwich (ABBA or BAAB) being chosen at random. The whole makes up the most complicated trial at East Malling.

By modern standards it is much too complicated. In the course of years trees are lost, complicating what was originally simple and making impossible what was complicated even in the first place ; so foresight is necessary, not only in making provision for changes of treatments, but for loss of trees. Nevertheless, this has been a very useful trial.

If it had contained fewer factors, the treatments could have been randomized without making the trial unmanageable.

The advantage of splitting the plots of this experiment lies in the small blocks obtained for the pruning treatments despite the large number of treatments altogether. In this way detailed investigation of effects like the interaction of rootstock and pruning and of the main effect of pruning becomes possible on account of the sacrifice of information about the main effect of rootstocks and other effects that are well understood already. In fact, splitting plots provides a means of putting emphasis where it is needed.

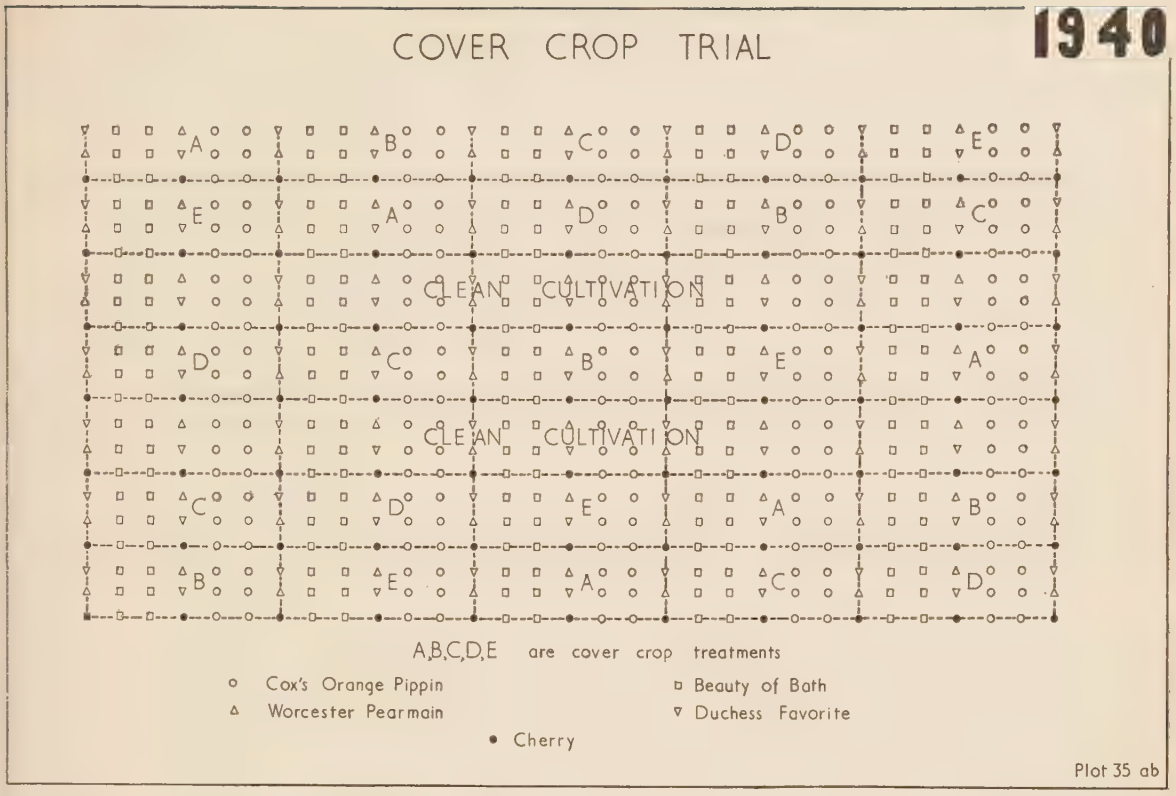


Phenomenal Berry and Loganberry Trial, 1934.

This trial, now grubbed, represents a split-plot design adopted for quite different reasons. Three methods had been proposed for dealing with Cane Spot on loganberries : spraying, training and the substitution of Phenomenal berry for the more usual variety. If the sole consideration had been emphasis, the varietal comparison (the one most likely to show a large effect) would have been assigned to the main plots, training to the sub-plots and spraying (the treatment least likely to be effective) to sub^2-plots. In this instance, however, the chief consideration was practicability.

A spray cannot conveniently be applied to any plot but a large one ; training needs appropriate wire-work, which should, if possible, occupy a whole row ; while varieties can be planted in any way desired. Accordingly, the four blocks were each divided into two main plots for spraying. Each of these main plots contained four rows, each of which formed a sub-plot for training ; while half a row formed a sub^2-plot for varieties. This trial well illustrates how the splitting of plots can be used to secure administrative convenience.

It will be noticed that the spraying treatments were arranged in two sandwiches, while the training treatments in each sandwich formed a Latin Square. These are restrictions on randomization that would be avoided to-day for the reason given in the discussion of the 1932 trial.



Cover Crop Trial, 1940.

After about 1935-36 there was a marked tendency for designs to become simpler, and this trial, intended to investigate the effect of perennial cover crops upon apple trees, has a straight-forward efficiency lacking in its predecessors. The designer had to face the difficulty that clean cultivation cannot be carried out in confined plots ; he therefore applied it as two columns supernumerary to those of the 5 x 5 Latin Square on which the cover crop treatments were disposed.

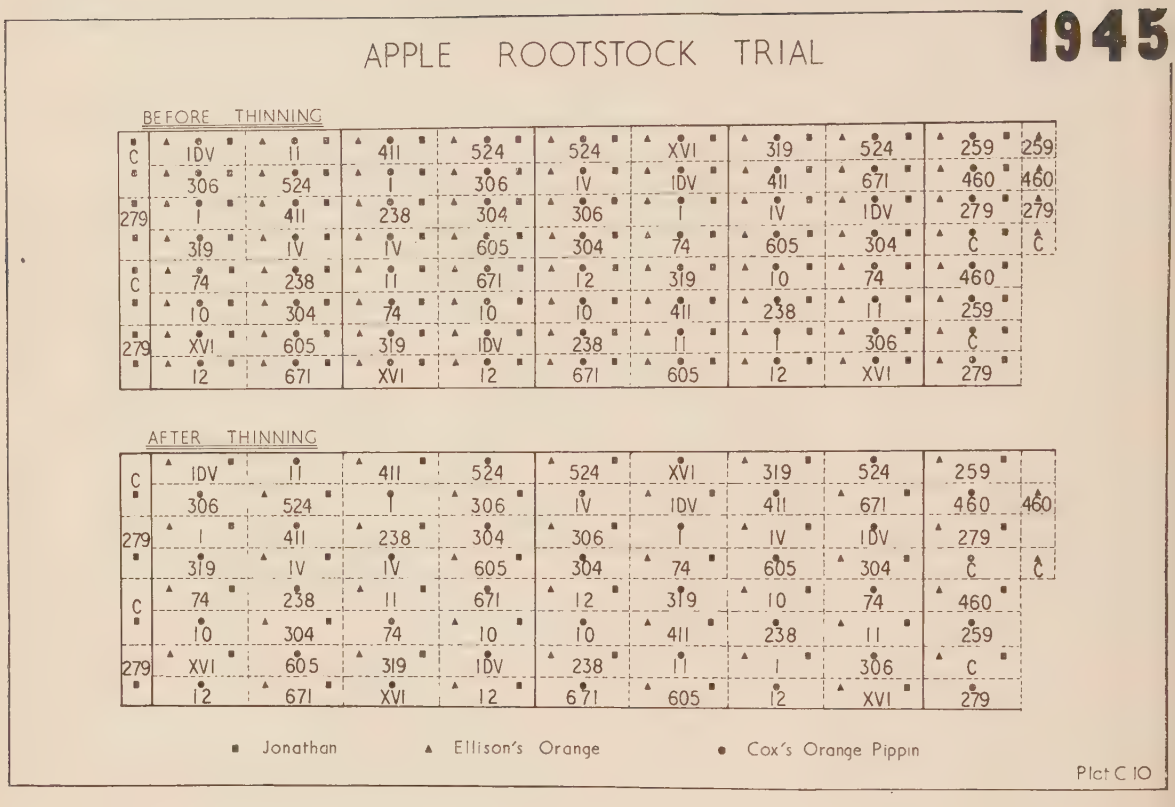
In such a trial there are really two questions to be answered :

(1) Does clean cultivation differ from the average of the cover crops ? This can be answered by comparing the totals of the two clean cultivated columns with those of the five having cover crops.

(2) Do the cover crops differ among themselves ? This can be answered by analysing the Latin Square. Apart from a lack of sufficient degrees of freedom for a really satisfactory consideration of the first question, the trial still seems well adapted to its purpose. More clean cultivated columns would have proved invaluable on several occasions, but, at the time of planning, it was expected that this effect would be too obvious to need demonstration.

When this trial was designed it was not expected that any analyses would ever be carried out in connection with the first question and consequently there seemed no point in choosing the two clean cultivated columns at random. They were, therefore, chosen on the basis of past performance, the third and fifth columns being selected because, on the average, they had behaved very like the other five.

In each plot there are ten trees and four varieties. The systematic arrangement of the varieties makes invalid any comparison of them. Despite the large plots this is rather a variable experiment.

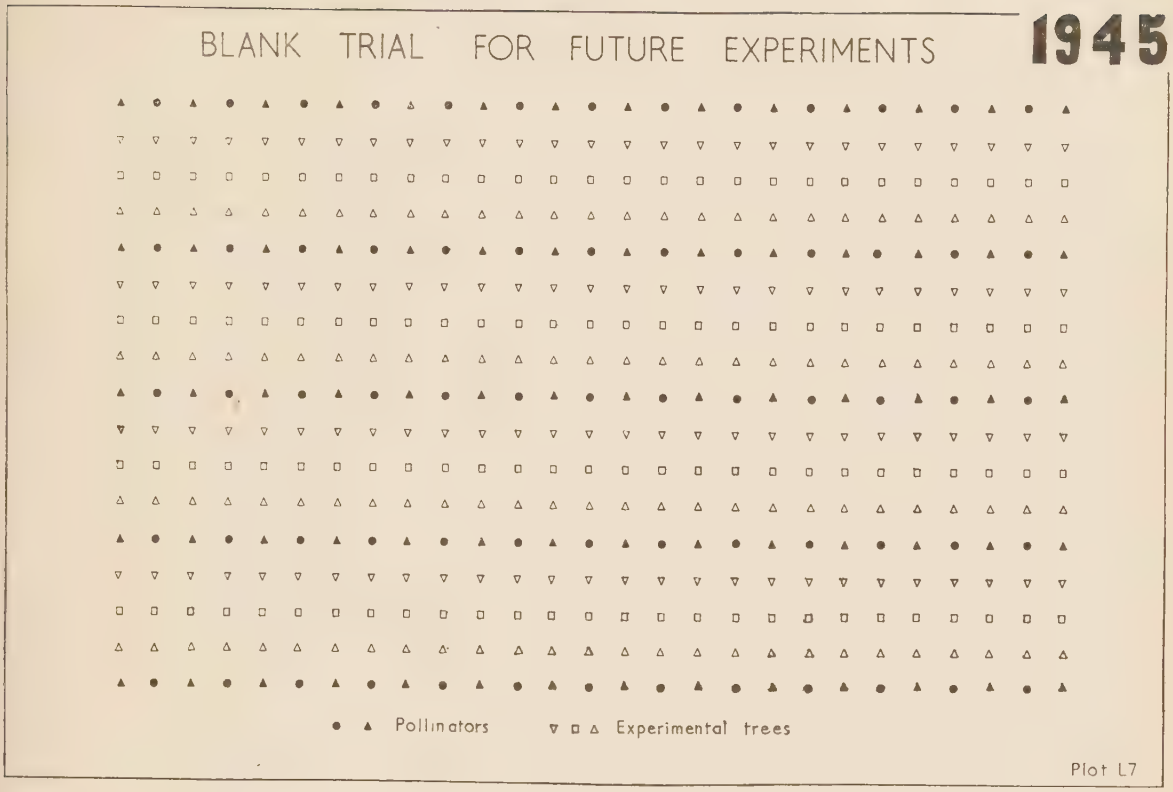


Apple Rootstock Trial, 1945.

This design shows another approach to the difficulty, already faced in the 1930 trial, of what to do when an experimental plantation needs thinning. There are sixteen rootstocks and three scion varieties. The first are to be compared and should therefore be randomized ; the scions, on the other hand, are included together only as a matter of convenience and may be arranged systematically. In the upper plan the varieties are disposed conveniently in rows to facilitate picking and there are four randomized blocks of the twelve rootstocks. In the lower plan alternate trees have been thinned leaving two randomized blocks. It is hoped that thinning will not become necessary because two replicates are hardly sufficient, but hard experience teaches the necessity of being prepared for every imaginable contingency.

The trial after thinning would consist of two properly randomized blocks. Before thinning, however, there would be restrictions on the randomization in order to leave a valid trial for the second period. There are reasons to believe that ordinary analytic methods would not be greatly in error, but a modified form of analysis has been devised that will take account of the effects of the restriction.

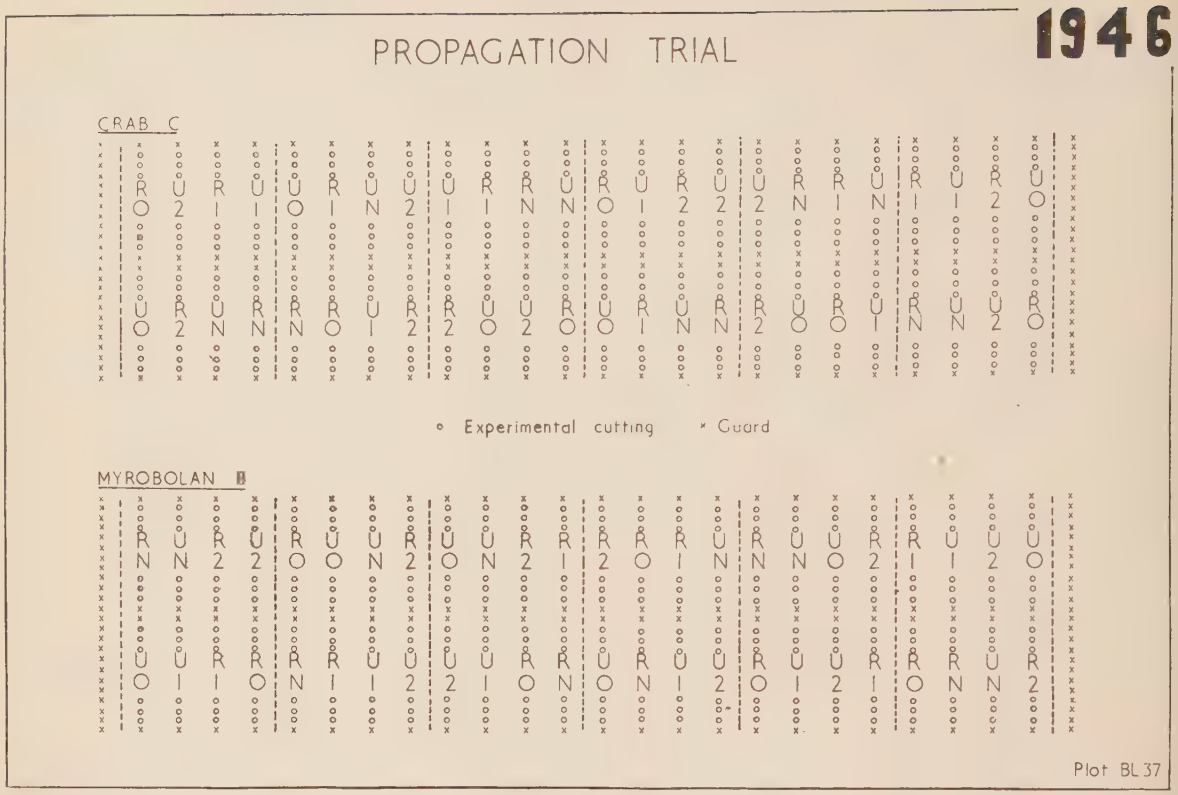
This experiment is a modern analogue of the 1919 trial. On both occasions there were three varieties and a range of rootstocks. In the earlier trial the varieties were separated, the trial illustrated being one of three, while all rootstocks were included together. In the later trial the varieties are included together while the rootstocks are compared in groups according to the forecasts of their vigour obtained by histological methods. Each group forms a separate trial.



Blank Trial for Future Experiments, 1945.

A difficulty with long lived plants is the time taken for them to become useful for experimental purposes. Thus, if it were decided in 1948 to establish an apple pruning trial, results could hardly be expected much before 1960. In order to overcome this lag it is now the practice at East Malling to lay down blank trials for, with the simple designs in vogue to-day, the planting plan of one trial is often not very different from that of its neighbour designed to investigate quite a different problem.

Such a blank trial is illustrated in the adjacent diagram. It has 108 plots of three trees representing three varieties, separated by rows of pollinators that will also do service as guards. If the treatments are such that all must be guarded, seven different designs are possible in randomized blocks according to the number of treatments desired and also one Latin Square. If no guards are needed, there are fourteen randomized block designs and one Latin Square. For a split-plot experiment in which the main plots must be guarded but not the sub-plots, the possibilities comprise eighteen randomized block designs and three Latin Squares. In all these cases, care has been taken to exclude from the count any design that could possibly be described as a " freak ". It appears how very flexible a blank trial can be made.



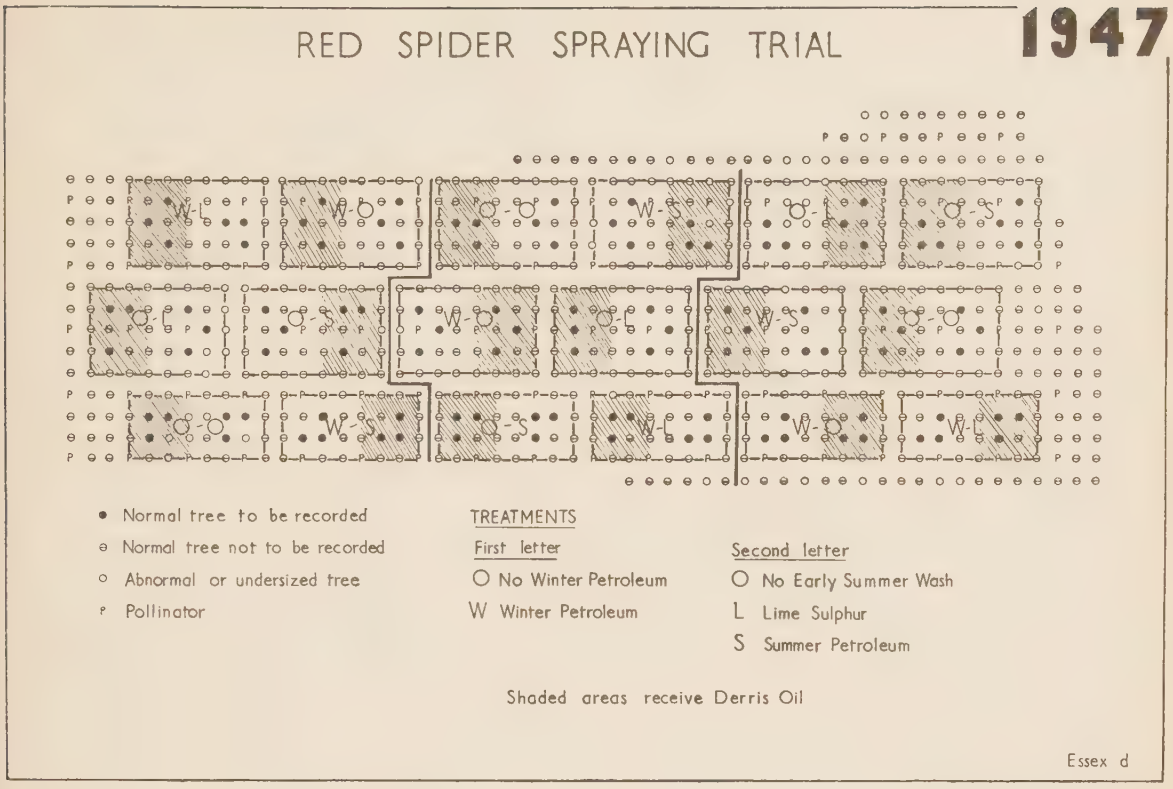
Propagation Trial, 1946.

This experiment represents a type of trial that is much more common now than formerly, the evolution of which has not been traced in the trials already discussed. It is concerned with the raising of cuttings and there are two factors, ringing (R) versus not ringing (U) and the application of two concentrations of growth substance in alcohol (1, 2), alcohol alone (O) or not treating at all (N). The trial is carried out in two parts, one with a freely rooting species (Myrobalan B) and one with a poor rooter (Crab C).

The difficulty with trials of this sort is to evolve a standard form that may be used for all. In any year it is more convenient to fit twenty or thirty trials on to a piece of land if they all need strips of similar size, while it is also more convenient to plant each year's experiments without having to lay out the land again and put in new pegs and paths. It is also easier for the farm workers at planting and lifting if all trials are of similar form. The propagation beds at East Malling are now laid out in strips four feet wide and cuttings are placed two inches apart in rows across the strips. The 24 cuttings to a row are divided into two plots each of twelve cuttings, the two end ones being intended to act as guards to the rest. This arrangement has proved very successful for cuttings, but might well have to be altered for different methods of propagation.

Since the most important record to be made concerns survival, it is not desirable to make the plots any smaller or the discontinuity of the measurements would become serious. As it is, an individual plot can give 50 per cent. survival or 60 per cent., it cannot give, say, 54 per cent. On the other hand, to make the plots larger would reduce the number of replicates possible, because the quantity of available material is often limited. Where other records are to be made, it is best to select at random a given number of survivors from each plot and to measure only them. Otherwise the results will represent the means of varying numbers of observations.

Such a trial represents the nearest approach to experiments with annual plants ever achieved with perennial species and there is not therefore the same need for simplicity on account of future contingencies. Even so a designer would be well advised to avoid complexity because of the difficulty of interpreting interactions in proportions based on small numbers.



Red Spider Trial Spraying, 1947.

For this type of trial also, the evolution has not been traced in the preceding examples. It is distinctive, first, in being a spraying trial and, secondly, in being planned for an already existing commercial plantation. This latter is, however, often a feature of spraying experiments.

The use of a commercial farm is frequently the best way of getting material for a trial like this, if not the only way. It enables the experiment to be situated where the pest is abundant, while it usually avoids any severe restriction on the total area that may be used. The chief disadvantages lie in the distance between the research worker and the trial, which may prevent adequate supervision and cause the cultural operations to be under the care of the farmer, who, although very co-operative, usually lacks any grounding in research procedure. The greater proportion of abnormal trees compared with an experimental plantation is another disadvantage.

In this trial the difficulty of spraying small areas has been met by making the plots large and then observing only a given number of trees from each, the selection being at random if there are more suitable trees than are needed for observations. (The plots, incidentally, are not all the same size.) The large blocks that result should not cause trouble with Red Spider where there is little correlation between the infestations of neighbouring trees, though they would be undesirable with a pest that was more localized in its incidence. The Derris is applied to sub-plots, the diagram showing clearly the arrangement of double guard rows both between main plots and between sub-plots. In designing a spraying trial it must be remembered that guards are needed both against the drift of spray and the spread of the pest or disease. Sometimes one is more important, sometimes the other.

Present Recommendations.

The chief difficulty of designing trials with perennial species lies simply in the fact that they *are* perennial, i.e. they are not replanted annually. Consequently, no trial should be laid down unless future conditions have been foreseen as clearly as possible. Designs should above all be *robust*, i.e. they should not be made useless by someone, perhaps twenty years afterwards, running a tractor into one of the trees. Also, what is nearly as important though not always possible, they should be *flexible*, i.e., they should be adaptable for other purposes when the original enquiry is finished. If a trial is planned without foresight, the designer is going to be reminded of his folly for decades afterwards—a thought that should have a powerful sobering effect.

To achieve these ends simplicity is essential at least in the basic conception. Here it must be emphasized that a " good " trial is one that validly investigates the problem set while involving a minimum of fuss, not one that uses the most complicated lay-out to be found in an advanced textbook. The designing of trials, in fact, should not be a display of statistical virtuosity.

The lay-out of most general usefulness is the randomized block design with or without split-plots. A serious outbreak of disease in one part of the field can usually be met by the omission of a complete block from the analyses of variance ; while the failure of one treatment does not invalidate the comparison of the rest, though admittedly, in a factorial design it can be very inconvenient. Missing plots can be easily dealt with even if there is more than one of them. The Latin Square, compared with randomized blocks, is not as robust and is much less flexible, but it may well be used in some circumstances.

Plot size is rather a vexed question. At East Malling the practice with apples and pears is to use single trees, though with plums two are desirable because of bacterial canker and silver leaf. If one of these diseases does break out few plots will be eliminated altogether, while those that retain both trees can always have one excluded at random from the list of trees to be measured, thus reducing the whole trial to single tree plots. The usual objections to such plots are their alleged high variability and the effect of shading, etc., of a tree upon its neighbour in an adjoining plot. To these objections there are several replies. If larger plots are used, high variability will result from the larger blocks. Given adequate spacing, " interference " effects are not serious. At worst they emphasize differences but do not cause them. Further, only by reducing the number of trees in a trial does it become possible to maintain the detailed records that should be considered essential. The recommendation of this paper is to use single-tree plots, but opinion on this point is by no means unanimous.

It should hardly be necessary to emphasize that many problems can be solved more quickly and cheaply in the laboratory than in the field. Histological examination of roots and biochemical techniques of injection have already been mentioned as means of avoiding the complications of a field trial.

The novice should be careful not to modify any lay-out he may read about until he is sure he thoroughly understands its theoretical basis. In general, he will not go far wrong if :

(1) He confines himself to designs in randomized blocks.

(2) He uses adequate replication. Four replicates should be the minimum. Also, no trial should have fewer than fifteen degrees of freedom for the error though twenty-five are desirable.

(3) He randomizes completely. If any restrictions are applied they should be of a kind for which an appropriate method of analysis has been evolved, e.g. split-plots.

(4) The design is practicable. The experimenter himself is the best judge on this point, which needs careful consideration. If the novice observes these recommendations he will at least have produced a valid trial and a fairly simple one. It may be that an experienced statistician could have done better, but a glance through the diagrams will show that " goodness " of design is all a matter of degree. The best of one period may be cited as a warning to the students of the next. This consideration should encourage the novice, if only by showing that there is no such thing as *the correct way*, however dogmatic the experts sometimes sound.

Acknowledgements.

The authors are much indebted to Miss J. M. S. Thom for the diagrams, which are based on the field plans actually used in carrying out the experiments.

Summary.

Developments in the design of field trials at East Malling are reviewed (1919-47) and illustrated by ten experiments chosen as being characteristic of their respective periods. The paper concludes with a summary of present recommendations on the lay-out of trials with long-lived fruiting plants.

PLANT PHYSIOLOGY

USE OF SPRAYS TO CONTROL FRUIT DROP*

II. EFFECT OF ADDING NAPHTHALENE-ACETIC ACID (NAA) TO A ROUTINE JUNE SPRAY

By M. C. VYVYAN and H. W. B. BARLOW†

Introduction.

The marked control of the so-called " June Drop " in Cox's Orange Pippin achieved in 1946 (Vyvyan and Barlow, 1947) by a spray of NAA (α-naphthalene-acetic acid) applied on 1st July, suggested the possibility that the NAA might be added to some routine insecticide or fungicide normally applied at about that time, thus avoiding the need for yet another spray.

This mixing of the sprays would be justified if it could be shown that the NAA and the routine spray are mutually compatible and would be a positive advantage if it were found that the NAA reduced the drop sometimes induced by certain sprays. It might be of particular value, for example, in the case of summer petroleum, which can give good control of Red Spider, but cannot safely be used in many districts because of the devastating drop of fruits and leaves it often brings about. Two experiments with NAA and summer petroleum have already been carried out at East Malling (Vyvyan, 1941 and 1946), but these gave inconclusive results as the oil happened to induce no additional drop in either experiment. Reports, however, have recently come in of successful control of the oil-induced drop in certain districts and further trials therefore seemed desirable.

Details of 1947 Experiments.

Two experiments were carried out in 1947, both on portions of the same plantation of 12-year-old trees, worked on M.IX and planted 12 ft. by 12 ft. The main variety was Cox's Orange Pippin, but every fourth row was Worcester Pearmain.

Treatments. The following eight treatments were tried :

OO.	Unsprayed control trees.
ON.	NAA (α-naphthalene-acetic acid) at 10 p.p.m. (parts per million).
LO.	Lead arsenate alone at rate of 2 lb. per 100 gallons.
LN.	Lead arsenate and NAA, as above, mixed.
SO	Dispersible Sulphur (proprietary brand) at $3\frac{1}{2}$ lb. per 100 gallons.
SN.	Dispersible Sulphur and NAA, as above, mixed.
PO.	Summer Petroleum (proprietary brand) at rate of 0·8 per cent. oil.
PN.	Summer Petroleum and NAA, as above, mixed.

Experiment I. Here only the four treatments OO, ON, LO and LN were tried and the NAA was used in the form of a proprietary brand of " anti-drop " spray. There were seven randomized blocks, each of four plots—one under each treatment. The plot consisted of twelve trees ; nine Cox's arranged 3 by 3 and three Worcesters.

Experiment II. Here all eight treatments were tried and the NAA was used in the form of the pure chemical. There were five randomized blocks of eight plots—one under each treatment. The plot consisted of five adjacent trees ; three Cox's and two Worcesters.

The sprays were applied on 18th June (Exp. II) and 19th June (Exp. I) the approximate dates recommended for codling control that season.

Records Taken. All previous drops were cleared away at the time of spraying and subsequent drops were collected periodically and counted and weighed. Except at the first pick-up—on 25th June —the dropped fruits were sorted into sound and unsound and the latter were further subdivided into those showing codling damage and those showing brown rot alone. Fruits showing both troubles were classed with the codling. The rotten fruits thrown down at the time of picking and many of those at the last pick-up were so severely infected with brown rot that it was impossible to be sure whether or

* The first in this series was Vyvyan and Barlow, 1947, *vide* References.

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not they had been previously damaged by codling ; here separation was not attempted. Certain of the fruits passed by the pickers and placed in the boxes showed slight codling or brown rot damage ; these were removed and sorted as in the case of the dropped fruits.

Where separation was possible, most of the unsound fruits showed codling damage, but as records for this are not complete, they are not given in this paper ; the two sorts of damaged fruits are grouped together as " unsound ".

Results with Cox's Orange Pippin.

The relative numbers of sound fruits picked and dropped and of unsound fruits picked are shown in Tables I, II and III respectively, where they are expressed as percentages of the initial total numbers of fruits present at the time of spraying.

The cumulative percentages of sound and unsound fruits, dropped under treatments OO, ON, LO and LN in the two experiments, are plotted in Fig. 1 and the mean percentage drops per day, period by period, are shown in Fig. 2. These values are on the simple interest basis, for the compound interest values (Q) (Vyvyan, 1946) cannot be calculated accurately for sound and unsound fruits taken separately where the relative numbers of these *on the trees* at successive dates are unknown and are likely to vary with the spray treatment.

The mean weights in pounds of 1,000 picked fruits under each treatment are shown in Table IV.

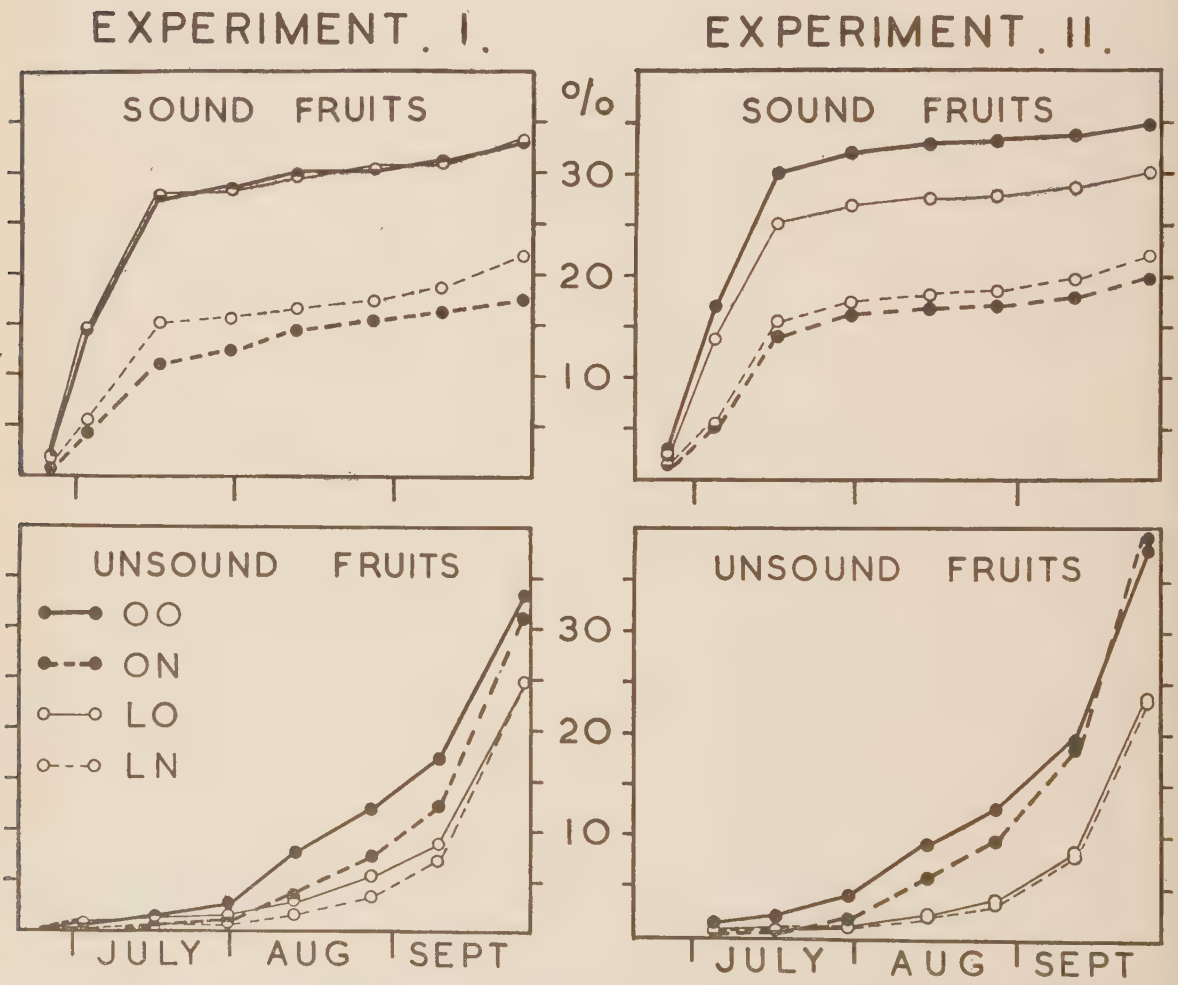

FIG. 1.

Cumulative percentage drop of sound and unsound fruits under the four treatments : OO (unsprayed), ON (NAA alone), LO (lead arsenate alone), and LN (lead arsenate + NAA).

NAA alone. Comparison of the values for OO and ON in Table I shows that NAA significantly increased the crop from 12 to 19 per cent. in Experiment I and from 15 to 25 per cent. in Experiment II. The corresponding values in Table II show that the increase in crop was brought about by a great reduction in drop from 34 to 18 and 33 to 19 per cent., which more than compensated for a reduction in the total percentage of sound fruit in trees sprayed with NAA. This may have been due to an increased infestation by the second generation of codling resulting from the retention on the trees of fruit attacked by the first generation.

In general, the results confirm those found in 1946 ; the NAA spray provided a considerable control of the " June Drop ", though the results were somewhat masked by the unusually severe attack by the second generation of codling.

Lead Arsenate with and without NAA. The values for the four treatments OO, ON, LO and LN were very similar in the two experiments. More sound fruits (Table I) were picked from trees receiving lead arsenate than from those receiving none, but the numbers dropped (Table II) were unaffected. Thus lead arsenate increased the crop by reducing the proportion of unsound fruits, whereas NAA increased it by reducing the drop of sound fruits.

The results further show that NAA and lead arsenate were completely compatible. If the values for the two treatments OO and LN in the two experiments (Table I) are pooled and compared with the pooled values for the two treatments ON and LO, the total in each case amounts to 93. This shows

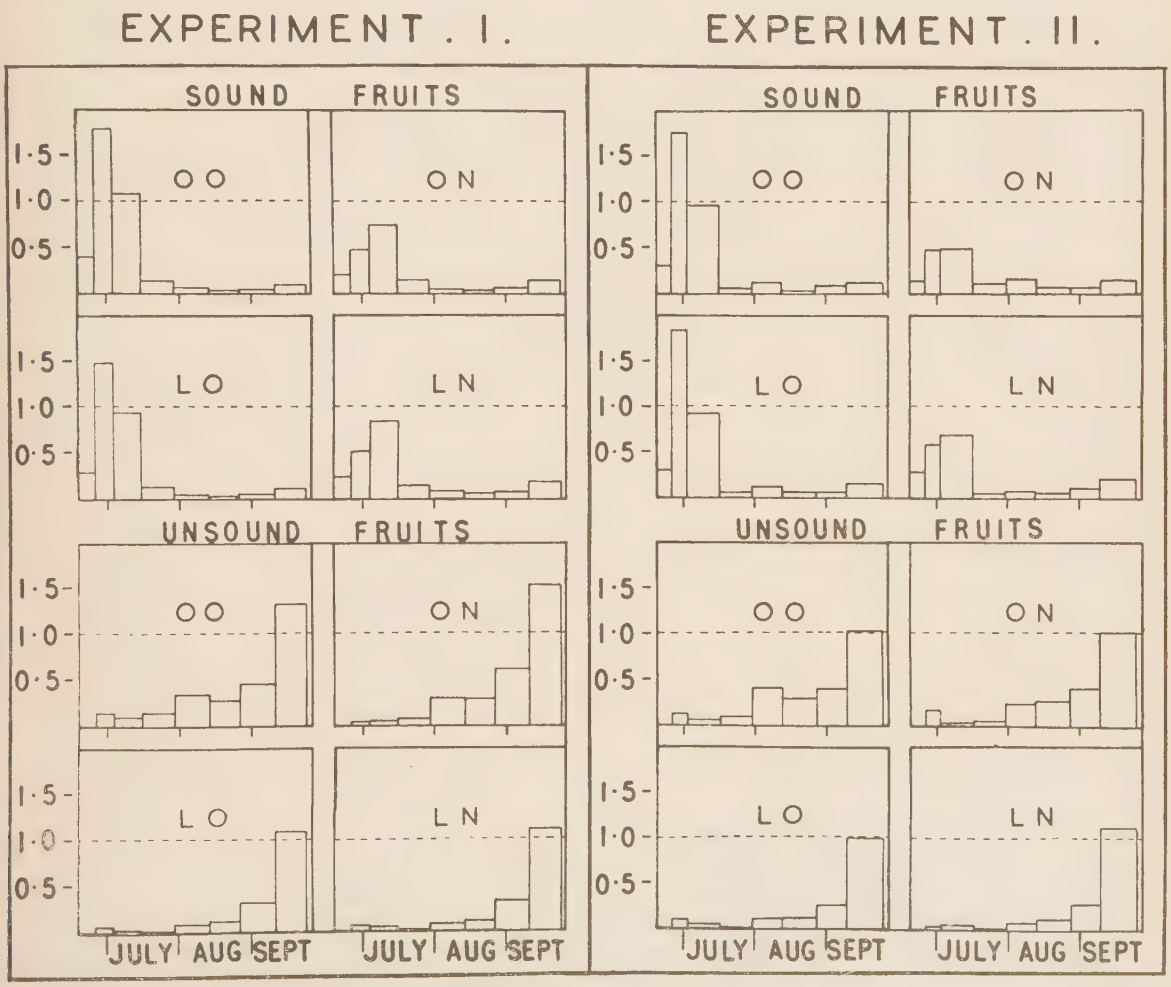

FIG. 2.

Mean percentage drop per day, period by period, of sound and unsound fruits under the four treatments : OO (unsprayed), ON (NAA alone), LO (lead arsenate alone), and LN (lead arsenate + NAA).

Table I.

Cox's Orange Pippin.

Sound Fruits Picked expressed as percentages of total numbers present at time of spraying.

Treatment.	Experiment I. Sprayed June 19th. Picked Sept. 25th.			Experiment II. Sprayed June 18th. Picked Sept. 24th.				
	No Insecticide or Fungicide.	Lead Arsenate.	Mean.	No Insecticide or Fungicide.	Lead Arsenate.	Dispersible Sulphur.	Summer Petroleum.	Mean.
Without NAA ..	12	27	20	15	22	17	16	17
With NAA ..	19	36	27	25	30	26	19	25
Signif. P = 0·05 ..	4		3	8				4
Diffs. P = 0·01 ..	6			11				6
Mean	16	31	23	20	26	22	18	21
Signif. P = 0·05 ..	3			6				
Diffs. P = 0·01 ..	4			8				

that a given amount of lead arsenate and of NAA applied to a given number of trees produced the same result whether half the trees received one substance and half the other (ON and LO) or half received both substances (LN) and half neither (OO). Lead arsenate did not reduce the anti-drop properties of the NAA, nor did the NAA reduce the insecticidal properties of the lead arsenate.

This suggests that NAA can safely be added to a lead arsenate spray, thus avoiding the need for yet another spray.

Table II.

Cox's Orange Pippin.

Sound Fruits Dropped expressed as percentages of total numbers present at time of spraying.

Treatment.	Experiment I. Sprayed June 19th. Picked Sept. 25th.			Experiment II. Sprayed June 18th. Picked Sept. 24th.				
	No Insecticide or Fungicide.	Lead Arsenate.	Mean.	No Insecticide or Fungicide.	Lead Arsenate.	Dispersible Sulphur.	Summer Petroleum.	Mean.
Without NAA ..	34	29	31	33	33	31	45	36
With NAA ..	18	20	19	19	22	20	27	22
Signif. P = 0·05 ..	4		3	7				4
Diffs. P = 0·01 ..	5		4	9				5
Mean	26	24	25	26	28	25	36	29
Signif. P = 0·05 ..	3			5				
Diffs. P = 0·01 ..	4			7				

The curves for cumulative percentage drops (Fig. 1) for sound and unsound fruits are widely different in form. In the one the values rise rapidly in June and early July and then flatten out; in the other, the values are at first low and then rise rapidly during the month before harvest—this rise representing the drop due to the abnormally heavy infestation by the second generation of codling.

The mean percentage drops per day, period by period (Fig. 2), show that the main loss of sound fruits occurred in the so-called " June Drop ", which took place during the last week in June and the first fortnight of July; there was little indication of any serious pre-harvest drop.

Table III.

Cox's Orange Pippin.

Unsound Fruits Picked* expressed as percentages of total numbers of fruit at time of spraying.

Treatment.	Experiment I. Sprayed June 19th. Picked Sept. 25th. No Insecticide or Fungicide.	Lead Arsenate.	Mean.	Experiment II. Sprayed June 18th. Picked Sept. 24th. No Insecticide or Fungicide.	Lead Arsenate.	Dispersible Sulphur.	Summer Petroleum.	Mean.
Without NAA ..	14	20	17	12	16	11	13	13
With NAA ..	22	18	20	18	19	17	15	17
Signif. P = 0·05 ..		6	4			6		3
Diffs. P = 0·01 ..		8	6			8		4
Mean	18	19	18	15	17	14	14	15
Signif. P = 0·05 ..		4				4		
Diffs. P = 0·01 ..		6				5		

* i.e. fruits slightly damaged by codling or brown rot ; values do not include the rotten fruits thrown down at time of picking.

In the case of the sound fruits the values for OO and LO, the treatments without NAA, are closely alike, and are widely different from those for ON and LN, the treatments with NAA. In the case of unsound fruits the converse holds good, the values for OO and ON are alike, and differ from those for LO and LN.

Dispersible Sulphur with and without NAA. Dispersible sulphur had no apparent effect on the percentages of sound fruits picked or dropped but did not decrease the reduction due to NAA. The values for SO and SN are almost identical with those for OO and ON respectively.

Table IV.

Cox's Orange Pippin.

Mean weight per 1,000 fruits at time of picking.

Treatment.	Experiment I. Sprayed June 19th. Picked Sept. 25th. No Insecticide or Fungicide.	Lead Arsenate.	Mean.	Experiment II. Sprayed June 18th. Picked Sept. 24th. No Insecticide or Fungicide.	Lead Arsenate.	Dispersible Sulphur.	Summer Petroleum.	Mean.
Without NAA ..	172	167	170	180	185	170	178	178
With NAA ..	151	148	150	154	147	178	150	157
Signif. P = 0·05 ..		24	17			23		12
Diffs. P = 0·01 ..		33	24			32		16
Mean	162	158	160	167	166	174	164	168
Signif. P = 0·05 ..		17				16		
Diffs. P = 0·01 ..		24				22		

Summer Petroleum with and without NAA. The results with summer petroleum were inconclusive The value for sound fruits picked (16 per cent.) for trees receiving petroleum alone (PO) was about the same as that for unsprayed trees (OO) ; the value (19 per cent.) for petroleum plus NAA (PN) was intermediate between those for treatments OO and ON and not significantly different from either. Petroleum applied alone resulted in a considerable increase in the total percentage of sound fruits, but this potential gain was lost in a greater percentage drop. Petroleum plus NAA gave approximately the same percentage of sound fruits as NAA alone but a larger proportion were dropped.

Relative Size of Fruits. The mean weights per fruit under the various treatments are shown in Table IV. In general, the fruits were smaller on trees receiving NAA—trees receiving petroleum in addition were the only exception. The differences in size, however, were not large, though they were usually statistically significant.

This reduction in size was apparently a direct effect of the NAA spray and not an indirect result arising from greater competition for food materials owing to the presence of larger numbers of fruits. For inspection of the values for the units within treatments showed that there was no apparent inverse relation between size of crop and mean weight of fruits.

TABLE V.

WORCESTER PEARMAIN.

Sound Fruits Picked and Dropped and Unsound Picked, as percentages of total numbers at time of spraying.

	Experiment I. Sprayed June 19th. Picked Sept. 25th.		Experiment II. Sprayed June 18th. Picked Sept. 24th.			
Treatment.	No Insecticide or Fungicide.	Lead Arsenate.	No Insecticide or Fungicide.	Lead Arsenate.	Dispersible Sulphur.	Summer Petroleum.
Sound Picked						
Without NAA	64	78	75	83	77	79
With NAA	64	82	78	83	76	76
Sound Dropped						
Without NAA	4	4	5	4	6	4
With NAA	3	3	4	3	4	5
Unsound Picked						
Without NAA	12	10	8	7	8	7
With NAA	17	9	10	8	11	9

Results with Worcester Pearmain.

These trees formed part of the same units and received the same treatments as the Cox's Orange Pippins ; but they were picked on different dates.

A picking gang removed all fruits of better colour on 20th August, the remaining fruits were picked on 4th September. It was thought that this procedure might reveal a difference in degree of maturity between trees under different treatments, as there is some evidence that NAA may hasten ripening. It was found, however, that about the same proportion of fruits was removed from each treatment at the first picking. Most of the " codling " fruit came off on this occasion owing to its higher colour.

The main results are summarized in Table V. The percentage drop of sound fruits was very low and about the same under every treatment, but lead arsenate considerably increased the crop by reducing the percentage of unsound fruits. No other treatment had any appreciable effect. In general, the drop was much less severe than is normal in this variety. It is possible that the early picking of the riper fruits may have been responsible for the abnormally low pre-harvest drop, moreover the final picking was itself rather early owing to market requirements.

Discussion.

Considerable control of " June Drop " in Cox's Orange Pippin has now been achieved in two consecutive seasons, under widely different weather conditions, with sprays of NAA at a strength of ten parts per million. Furthermore the evidence in this paper suggests that it will be possible to avoid the expense of an additional spray by adding the NAA to a routine lead arsenate or dispersible sulphur spray normally applied at the appropriate time.

This possible extension of the use of anti-drop sprays raises the question of their place in horticultural practice.

In the case of the Pre-harvest Drop, the problem is relatively simple. The fruits at that time are nearly full grown and they can have little further effect on the tree, or on one another, whether they fall or not. If the trees are bearing a fair crop and there is a chance of a considerable fall, a spray is

worth while as an insurance policy, provided the variety is one that responds to such a spray. There will be danger only if the crop is so heavy that a little increased weight might break the branches. If the crop is very light, however, a spray will not be worth while since the possible gain in crop would not meet the expense.

In the case of " June Drop " and the " First Drop " after petal-fall—should control of this become possible—the problem is more complex. The young developing fruits serve other purposes in the economy of the tree besides providing a potential crop. During the first few weeks after petal-fall the numbers present, in relation to the size of the tree, must not be below a certain minimum, nor exceed a certain maximum, if an optimum number of fruit buds are to be formed, otherwise the tree may be in an " on " year or an " off " year next season and may develop a biennial rhythm of alternating heavy and light crops. After this period the growing fruits are still competing for available food materials and thus influencing one another's rate of growth. If there are too many they may remain small and poor in quality; if they are too few—as in an " off " year, they may become too large and remain immature. Although there may be considerable latitude at each stage in the numbers required for optimum performance, it is probable that the minimum for some stages exceeds the maximum for some later stages. In the apple, for example, each truss carries four, five or more blossoms, yet one fruit for every third or fourth truss is usually enough to give a full crop. If, however, the fruits were thinned to that number at the start, the tree would probably have a severe " on " year the next season and very likely overgrown fruit in the current year. Fortunately a progressive adjustment of the number of fruits as they increase in weight seems often to occur naturally, but the mechanisms concerned, whatever they may be, seem to be influenced greatly by local soil and seasonal weather conditions and, as a result, the drop may sometimes be too great or too little. Here artificial means may be required to adjust the balance where natural conditions have failed. The practice of thinning fruitlets where the crop is too heavy is an old established one, the use of anti-drop sprays to control " June Drop " should be regarded as a converse practice to be used when the crop is in danger of becoming too light. It may also prove to be of value when used in conjunction with thinning, allowing this process to be carried out with greater precision and boldness because of a lessened danger of subsequent heavy drop.

Obviously the sprays should not be used where the crop is already too heavy, but trees in such a condition should be carefully watched for the onset of a heavy " June Drop " and sprays should be ready in case this should develop. For the mechanism responsible for " June Drop " seems to be bound up with the competition between the various fruits and, if there are far too many of these, the processes that result in abscission may be initiated in too large a proportion of the fruits and result in too heavy a drop.

So far, however, worthwhile control of " June Drop " has only been achieved in Cox's Orange Pippin and this is a variety that is not likely often to carry too heavy a crop.

Acknowledgements.

The authors wish to express their thanks to Mr. S. C. Pearce for advice on the planning of the experiments and on the statistical analysis of the results. They are also particularly indebted to Mr. G. F. Trowell and Mr. J. Larking who were responsible for most of the tedious work of collecting, sorting and counting the drops and of summarizing the results, and to Mr. G. Evans who gave valuable help in rush periods.

Summary.

Sprays of NAA (α-naphthalene-acetic acid) at 10 p.p.m. applied in late June greatly reduced " June Drop " in Cox's Orange Pippin and increased the crop. NAA was as effective when added to a spray of lead arsenate or of dispersible sulphur as when applied alone. Addition of NAA to summer petroleum gave inconclusive results. In the case of Worcester Pearmain, NAA had no effect on " June Drop " but lead arsenate reduced drop by controlling codling moth.

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USE OF SPRAYS TO CONTROL FRUIT DROP

III. EFFECT OF 2,4-DICHLORO-PHENOXY-ACETIC ACID AND A RELATED SUBSTANCE ON FRUIT DROP IN BRAMLEY'S SEEDLING

By M. C. VYVYAN and H. W. B. BARLOW*

Introduction.

Recent work (Batjer and Marth, 1945, Batjer and Thompson, 1946) has shown that sprays containing 2,4-dichloro-phenoxy-acetic acid (sometimes shortened to DPOA or to 2,4-D) are very effective in controlling pre-harvest drop in the apple varieties Winesap and Stayman but are of little use with other varieties so far tested. They proved ineffective with Cox's Orange Pippin in 1946 (Vyvyan and Barlow, 1947).

In some small scale trials with fourteen different growth substances in 1946, this substance proved outstanding in delaying the abscission of de-bladed leaf stalks of Bramley's Seedling. It again proved very effective in further trials carried out in May, 1947 (Barlow, 1948, this Report p. 121), with a larger number of growth substances on de-blossomed Bramley's pedicels ; 2-methyl-4-chloro-phenoxy-acetic acid proved nearly as effective.

It was therefore decided to carry out field trials with these two substances to test their effect on " June Drop " in Bramley's Seedling.

Plan of Experiments.

Mature trees bearing a heavy crop were used and, to reduce the danger of spray drift, only alternate trees in alternate rows were included. There were twelve blocks, each consisting of six experimental trees. Two trees (D5 and D1), at random in each block, received 2,4-dichloro-phenoxy-acetic acid at concentrations of 5 and 1 parts per million respectively ; two (C5 and C1) received 2-methyl-4-chloro-phenoxy-acetic acid at the same two concentrations, and the other two were left unsprayed as controls. The sprays were applied on 17th June at the rate of eight gallons per tree. After spraying, the ground under the trees was harrowed to bury previous drops, and rolled to provide a smooth surface for the easy collection of subsequent drops. These were collected at intervals and counted and weighed.

Early in August it became evident that treatment D5 was having some effect and treatments C5 and C1 were having none. It was decided therefore to use the trees under these two treatments, and one of the two unsprayed trees in each block, in a second experiment designed to show the effect of sprays of 2,4 dichloro-phenoxy-acetic acid, applied in August, on subsequent drop. Two trees (D5 and D10) out of the three in each block were sprayed, at 5 and 10 parts per million respectively, the other was left unsprayed as a control. These sprays were applied on 19th August. To avoid the possibility of bias arising from an after-effect of the original treatments, the twelve trees under each of these were distributed evenly between the three new treatments. The fruits were picked on 8th October. It was impracticable to count all the fruits picked from each of the 72 trees so the numbers had to be estimated. This was done by weighing a random sample of 100 fruit from each tree and determining the total weight of crop from that tree.

Results.

The results are given in Tables I and II. In Table I the drops and picked fruits are shown as percentages of the estimated total numbers of fruits present at the time of the first spray (17th June). The trees subsequently used for the second spray treatment are arranged here according to their original spray treatments. It is clear that the trees under D5 yielded an appreciably greater final crop, mainly through a reduction in drop before 19th August. No other treatment applied on 17th June had a noticeable effect. After adjustment for differences in the initial numbers of fruits at the time of the first spray (17th June), the yield per tree was 9·0 bushels from the unsprayed and D1 trees and 10·3 from the D5. In Table II the drops and picked fruits are shown as percentages of the estimated total numbers on the trees at the time of the second spray (19th August), and the trees are

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TABLE I.

EFFECT OF FIRST SPRAY (APPLIED 17TH JUNE).

Percentages based on estimated numbers of fruits present on that date.

NOTATION :—D.1, D.5, D.10 = 2,4-dichloro-phenoxy-acetic acid at 1, 5, and 10 parts per million.

C.1, C.5 = 2-methyl-4-chloro-phenoxy-acetic acid at 1, and 5 parts per million.

Number of Trees.	Treatment at First Spray, 17th June.	Treatment at Second Spray, 19th Aug.	Drops up to 19th Aug.	Drops after 19th Aug.	Picked Fruits.
			%	%	%
12	D.5	Nil	15	21	64
12	D.1	Nil	22	22	56
12	Nil	Nil	23	21	56
12	Nil	4 trees under each Treatment (D.5, D.10 nil)	25	(20)	(55)
12	C.5		23	(18)	(59)
12	C.1		24	(19)	(56)

arranged according to their treatments on that occasion. Again the trees sprayed with 2,4-dichloro-phenoxy-acetic acid at 5 parts per million yielded a somewhat larger crop ; no further gain in crop was achieved by increasing the concentration of the spray to 10 parts per million.

After adjustment for differences in numbers of fruits at the time of the second spray (19th August), the yield per tree was 8·4 bushels from the unsprayed and 9·6 from the sprayed (D5 and D10).

Discussion.

The results show that a spray of 2,4-dichloro-phenoxy-acetic acid, applied in mid-June, may produce an appreciable reduction in drop during the next two months, and that the resulting gain in crop may be maintained, though not increased, during the subsequent period up till harvest. They also show that a spray of the same substance, applied in August, may likewise result in a greater crop. The gain in crop, however, was not very great in either case. It amounted to just over one bushel a

TABLE II.

EFFECT OF SECOND SPRAY (APPLIED 19TH AUGUST).

Percentages based on estimated numbers of fruits present on that date.

NOTATION, as in Table I.

Number of Trees.	Treatment at First Spray 17th June.	Treatment at Second Spray 19th Aug.	Drops after 19th Aug.	Picked Fruits.
			%	%
12	D.5	Nil	25	75
12	D.1	Nil	28	72
12	Nil	Nil	28	72
12	4 trees under each treatments, (C.5, C.1 and Nil).	Nil	32	68
12		D.5	23	77
12		D.10	22	78

tree or about eighty bushels per acre. It is possible that a spray applied in June, followed by another applied in August, might jointly provide a worth-while effect. No recommendations for the use of these sprays on a commercial scale can be made as yet, especially as some recent work (Bryant *et al.*, 1947, Marsh and Taylor, 1947) has suggested that this substance, 2,4-dichloro-phenoxy-acetic acid, may sometimes have a harmful effect on the tree and cause malformations in the fruit. More work on this subject must be done before these sprays can be passed for general use.

Acknowledgements.

The authors are again indebted to Mr. S. C. Pearce for advice on the planning of the experiments and to Mr. G. F. Trowell and Mr. J. Larking for recording and summarizing the results.

Summary.

Sprays of 2,4-dichloro-phenoxy-acetic acid resulted in an appreciable reduction in drop in Bramley's Seedling, whether applied in mid-June or in mid-August. Use of such sprays is not recommended at present.

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USE OF SPRAYS TO CONTROL FRUIT DROP

IV. NOTE ON THE AFTER-EFFECTS OF A NAPHTHALENE-ACETIC ACID (NAA) SPRAY ON THE RIPENING OF STORED CONFERENCE PEARS

By M. C. VYVYAN, C. WEST and H. W. B. BARLOW

Introduction.

There is evidence that NAA (α-naphthalene-acetic acid) sprays may sometimes hasten the ripening of apple fruits and influence their keeping quality in store (Batjer and Moon, 1945), but tests carried out at the Ditton Laboratory have revealed no such after-effect of this spray in the case of the apple varieties Bramley's Seedling (Vyvyan, 1946) and Barnack Beauty (Vyvyan and Barlow, 1947).

Recent results in the U.S.A. (Gerhardt and Allmendinger, 1945), however, have shown that this spray may have a considerable effect on the storage life of the fruits of the pear Williams' Bon Chrétien (Bartlett), when picked late. A storage trial was therefore carried out with sprayed fruits of the Conference pear, as it has already been shown (Vyvyan, 1943) that this spray can keep these fruits on the trees for some weeks after the normal picking date.

TABLE I

EFFECT OF A NAA (α-NAPTHALENE-ACETIC ACID) SPRAY AND OF THE DATE OF PICKING ON THE SUBSEQUENT RIPENING OF CONFERENCE PEARS IN STORE

Date of gathering.	Average weight of fruit when gathered (gm.)	Treatment.	Condition of fruit when examined.	
			On removal from 37° F. (27.11.47).	After a further week at 65° F. (4.12.47).
16.9.47	89	Sprayed	Firm, unripe, slight yellowing, some shrivelling.	Just ripe to ripe, shrivelled, no wastage.
	89	Unsprayed	ditto.	ditto.
23.9.47	91	Sprayed	Unripe, slight yellowing.	Ripe to melting ripe, good flavour, juicy, no wastage.
	89	Unsprayed	ditto.	ditto.
30.9.47	92	Sprayed	Unripe, yellowing, and softening.	Ripe to melting ripe, excellent flavour, soft, very juicy, 1 per cent. wastage.
	95	Unsprayed	ditto.	ditto. 1 per cent. wastage.

N.B.—A later examination, on 17.12 47, confirmed exactly the findings of the earlier one.

Plan of Experiment.

Thirty mature trees were used, arranged in five blocks, each consisting of two plots of three trees. One plot in each block was sprayed with NAA at 10 parts per million on 27th August, the other received water alone, as a control. The fruits from one NAA and one control tree in each block were picked on 16th September, those from another on 23rd September—which was the normal picking date—those from the remaining trees on 30th September. Two samples of 100 fruits from each of the NAA and control trees were sent to the Ditton Laboratory at the time of each picking, where they were stored without delay in air at 37° F. Fruits less than $1\frac{3}{4}$ inches in diameter were not included in these samples. Owing to the exclusion of these small fruits, the mean weight per fruit was slightly greater in the samples than on the trees as a whole; the values were 91 gm. and 75 gm. respectively. In neither case was there any difference in weight between those from sprayed and unsprayed trees. Fruits from the last picking were slightly, but not significantly, heavier than those from the earlier pickings.

Results.

The storage results are given in Table I. They show that there were no differences in storage behaviour or in physiological condition between treated and untreated fruits picked at any one date. There were, however, considerable differences between those picked at different dates. The best quality was shown by the fruits picked a week late—on 30th September. This result suggests that NAA may safely be used to prevent pre-harvest drop in Conference pear, and even to postpone the picking date.

Summary.

A spray of NAA had no after-effect on storage behaviour of fruits of Conference pear, picked a week early, at the normal date, or a week late. Late picking gave the best quality.

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THE STUDY OF AUXIN IN SHOOTS OF APPLE AND PLUM

By E. S. J. HATCHER*

Introduction.

In 1946 a direct study of fruit tree hormones was begun at East Malling with an auxin survey of growing shoots of apple and plum. Auxins are characterized by their influence on the process of cell extension, on which the assay method of biological estimation is based. The immediate aim of the investigation was to correlate the growth behaviour of the shoot with its auxin status.

Vegetative shoots were selected first for study to avoid the additional complication of fruit bud formation, and the consequential interaction of vegetative and reproductive phases of development. The varieties used were the Myrobalan B plum and the Crab C apple rootstocks, which are also employed in research on propagation (Hatcher and Garner, 1948). The results cover two growing seasons (1946 and 1947) and the present account is preliminary to full publication. It will be evident that this auxin study is in no way complete ; ultimately it will be extended to other parts of the tree including the roots.

Methods.

A modification of the standard coleoptile method was used for auxin estimation (Went and Thimann, 1937 ; Hatcher, 1945), the hormone being collected from stem sections into agar plates, then cut into blocks for unilateral application to the coleoptile. Exhaustive collection of auxin was not carried out, but a standard collection time of one hour was used over which auxin is released at a fairly steady rate. Such procedure is normally referred to as the diffusion technique, a misleading term, for while once the auxin enters the agar its further movement through the plate is by true diffusion, movement in the stem or coleoptile is not simple diffusion, but a process intimately concerned with living tissues and exhibiting polarity. This was shown most effectively with the stem sections under consideration, for auxin is released by them only basipetally through their lower surface. A further standard adopted was that of a stem section 1 cm. in length, the present survey examining the rates of auxin release, as distinct from absolute amounts of the hormone present, which would necessitate an extraction method. To obtain auxin concentrations in the agar within the range having a proportionate relation with coleoptile curvature, the size of the plate was varied, usually to 2, 4 or 8 times that of the unit agar block.

Results.

A. Plum Shoots.

The experimental methods just described were developed during some preliminary observations made in May, 1946, on lateral shoots of one-year Myrobalan B plants from hardwood cuttings. Auxin was present in all parts of the shoot and it was decided to carry out systematic sampling of three different zones, tip, middle and base. It soon became evident, however, that the shoots had almost completed their extension growth when first sampled in this way, at which time the auxin release rates were high, with a definite gradient down the shoot. After this the auxin values rapidly declined at all points, though most rapidly at the tip, which, therefore, fell behind the middle zone. By mid-June the auxin release rates were low throughout the shoot and by the end of July were no longer measurable.

During 1947 shoots growing up from a layer-bed were examined throughout their extended period of development. The final length attained was over 160 cm. (compared with about 20 cm. growth of the laterals) and about 100 leaves were produced. These shoots formed branches, a characteristic growth habit of this plum variety. Adequate sampling became more and more difficult, for only a limited number of observations could be made, but it was possible to obtain a general picture of the auxin trends through the season in the main shoot.

In the early stages there was a general auxin build-up in the shoot, though marked tip dominance of auxin was not displayed and it became evident that auxin distribution along the shoot was manifesting a double peak, in the regions of the tip and base. This is shown clearly in Table I, where the results

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from four shoots taken on 30th May are given. The lower peak is associated with the initiation of branching in this region of the shoot, and, as lateral growth proceeded, the auxin release rates from the upper part of the main shoot fell to very low values. This was only a temporary effect, however, and by mid-August high auxin rates were again found in the upper internodes. Data relating to the fifth internode from the tip of the stem are plotted in Fig. 1, a striking demonstration of the " effect " of branching on the auxin trends in this region. Eventually the auxin release rates declined throughout the shoot, least rapidly in the branching zone. Summing up it can be said that wherever extension growth was occurring auxin could be detected and that generally, as in the lateral shoots, such growth had ceased some while before the complete disappearance of the hormone.

TABLE I.

AUXIN RELEASE RATES IN MYROBALAN B LAYER-BED SHOOTS JUST PRIOR TO VIGOROUS LATERAL GROWTH.

High auxin values are found at the tip and at the branching region near the base.

Position in Shoot.	1	2	3	4	Mean.
Tip	62	88	84	46	70
Fourth Internode ..	30	32	44	34	35
Eleventh Internode ..	51	35	42	33	40
Base	97	72	82	45	64

B. Apple Shoots.

Stoolbed shoots of the Crab C rootstock were surveyed in both 1946 and 1947. Such shoots attain about 150 cm. in length, produce about 50 leaves and are characteristically unbranched. While in the very early stages of growth, when the shoots were some 5 cm. in length, a definite auxin dominance in the tip was evident, this gave place quite quickly to a " build-up " of maximum auxin in a region lower down the stem, corresponding to the fifth or sixth internode. This region can be regarded in general as that associated with the highest auxin release rates, with a falling gradient downwards ; but from a comparison of the observed auxin values for the two successive years, it is clear that the auxin gradient along the stem during growth varies significantly with season. In the first year the auxin release rates progressively declined from July to October, while along the stem there was a marked fall in auxin by the fifteenth internode, with no hormone detectable at the twentieth internode. In the second year, while the maximum auxin values determined approximated to those found in 1946 and were located in precisely the same region of the stem, marked contrasts were observed in trends in the auxin release rates during growth. The results can be summed up by stating that in 1947 high auxin values were found for a much greater proportion of shoot length and for a much longer period. Thus even in the twenty-fifth internode, where in 1946 no auxin was detectable, quite high values were found and for a short period towards the end of the season as far fown as the thirty-fifth internode as well. However, by reason of a sharp decline in October the final disappearance of the auxin compared with 1946 was not delayed, as shown in Fig. 2.

In addition to the build-up of auxin late in the 1947 season, particularly in relatively low regions of the shoot, another feature of the results in this year was the large fluctuations in the auxin values. This on examination appeared to be connected with the high but fluctuating sun-hour records of the period from August onwards. In 1946 the corresponding period was dull and rainy, and was paralleled by the slow and steady decline in the auxin release rates. The inference to be drawn is that the auxin release rate in some manner reflects the environmental conditions obtaining during a limited period previous to taking the shoot for analysis.

Reference has been made to the unbranched habit of the Crab C rootstock and, not unexpectedly, this can be related to the auxin values, there being no early build-up of auxin in the basal region of the young shoot so characteristic of the Myrobalan B shoots (see Table I). Corroborative evidence of the relationship between auxin and branching was sought, and found, by comparing selected branched and unbranched shoots of both these stocks, and further, by comparing two other plum varieties, Brompton which is typically unbranched, and Marianna which is one of the most branched of all stocks.

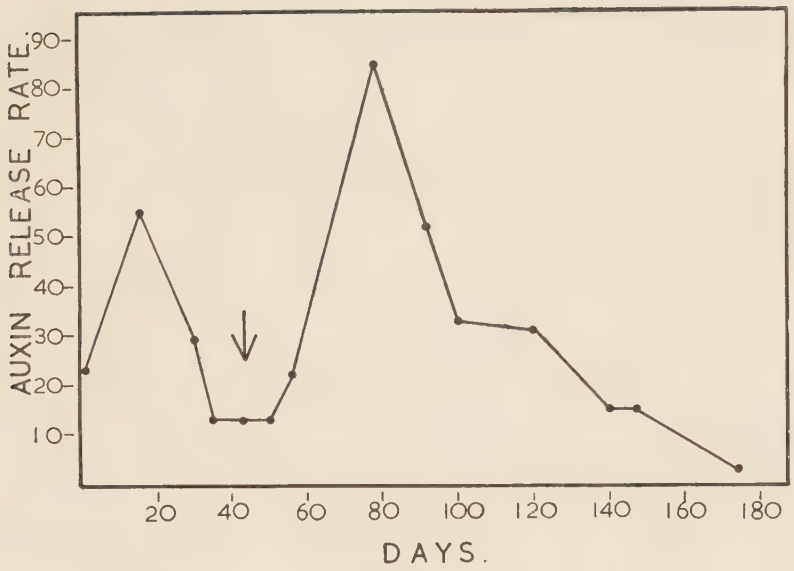

FIG. 1.

Auxin release rates in Myrobalan B layer-bed shoots determined throughout growth at the 5th internode from the tip. The onset of vigorous lateral growth is accompanied by a temporary depression of the auxin values in the upper region of the shoot.

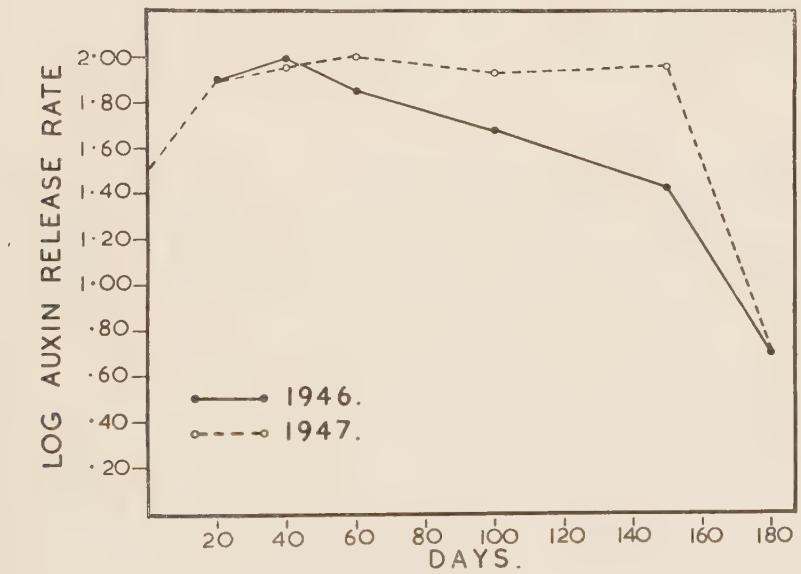

FIG. 2.

Auxin release rates in Crab C stool-bed shoots for the seasons 1946 and 1947. Logarithmic values are plotted for various times during growth and indicate that while high values were maintained for a much longer period in 1947, final disappearance of the auxin was not delayed.

Discussion.

These results are in line with the conception of auxin as a hormone intimately associated with cell extension as distinct from cell division. The extending shoot releases auxin basipetally from the lower surfaces of isolated sections at rates reflecting position in the shoot, and the growth behaviour of the shoot at the time of auxin estimation. It would appear, however, that while auxin is always released from a region of the shoot in process of extension, the reverse does not always hold, for active extension growth may subside quite a considerable time before the auxin release rate falls below the limit of detection. Detailed growth measurements were not made but it is quite evident that environmental conditions which influence the growth of the shoot also affect the auxin release rates. Furthermore the growth pattern of the shoot, with the degree of branching as criterion, is reflected in the auxin gradients along its length. This last point is of some interest in the study of growth and form of cuttings in relation to soil and spacing (Garner and Hatcher, 1947).

Such findings pose two further questions, first as to the origin of the auxin in the shoot and, second, as to its ultimate fate. The auxin values being considered were determined on the stem tissues proper, so, bearing in mind the polar movement of the hormone, the terminal bud and the leaves were examined as possible sources, with results pointing definitely to the conclusion that auxin must be produced autonomously in the stem tissues. With regard to its eventual fate, polar release from isolated sections suggests continuous downward movement in the plant, yet, in the absence of branching, a falling auxin gradient has been demonstrated from a region below the tip downwards, with no real evidence of a basal accumulation of auxin. Sometimes, however, auxin disappears last from a region well down the shoot simulating a slight auxin accumulation. Final judgment on the source and fate of the auxin should await information on the absolute amounts of the hormone present in the stem tissues, and as the shoot is probably not a closed auxin system, its hormonal relationship with the root will also have to be considered.

This initial survey of auxin in the shoot will lead, it is hoped, to a more elaborate study of the metabolic role of the hormone. A different aim will be a link up with considerations of the effects of horticultural treatments, such as pruning, on the natural hormone relations. The experimental basis of the findings here briefly sketched, together with additional data of a like nature, will be presented fully elsewhere.

Acknowledgements.

I wish to acknowledge the assistance of Miss M. R. Rawes throughout this work and the help of Mr. G. Evans in the routine but important task of growing the Avena test objects.

Summary.

The early experiments in a direct study of hormones in the fruit tree are described. These take the form of a survey of auxin release rates in vegetative shoots of plum and apple rootstocks. The relationship between the growth of the shoots and their auxin values is shown and also how the growth pattern of the shoot, with the degree of branching as a criterion, is reflected in the auxin trends. It is found that the auxin values are influenced by external conditions, notably the seasonal environment of the shoot.

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GROWTH SUBSTANCES IN THEIR RELATION TO HARDWOOD STEM CUTTINGS OF FRUIT TREE ROOTSTOCKS

By E. S. J. HATCHER* and R. J. GARNER

Introduction.

This paper deals with an aspect of the hardwood stem cutting method of fruit tree rootstock propagation. Its purpose is to indicate how growth substances are being used in this method of propagation, and to provide an introduction to later reports on the inter-relations of the factors concerned in the regeneration process.

Historically the introduction of synthetic growth substances in 1935 opened a new phase in vegetative propagation research. By 1939 a very large number of experiments with a great variety of plants had been carried out which were reviewed by Pearse (1939b). The effect of growth substances as root stimulants was established, but it became evident that this action by itself was insufficient to ensure response in all plants, especially in the case of hardwood cuttings ; the so called shy-rooting subjects appeared still to be beyond the scope of this method of propagation. Fruit rootstocks were of this category, and summarizing experiments with various plum rootstocks Pearse (1939a) records that " in no instance was the percentage of cuttings rooting significantly increased by the treatments ". Subsequent hardwood cutting experiments by Sinha and Vyvyan (1943), provided some evidence that under certain conditions a positive rooting response was obtainable with plum stocks, but with apple stocks no significant effect was observed. Reviewing the hardwood cutting experiments of recent years at East Malling, Vyvyan (1943), concluded that " in most cases there was no improvement in rooting ", and Garner (1944) in his description of the general methods of rootstock propagation did not include growth substance treatment in the routine technique for hardwood cuttings. This was the position at East Malling in 1943 when, after an interval of three years due to the war, research on vegetative propagation of rootstocks was renewed. It is still the general position to judge from other published work ; for example, in a recent paper, Zimmerman and Hitchcock (1946) state that " hardwood apple cuttings have been the subject of much investigation, and attempts have repeatedly failed to develop methods to force apple stems to form roots."

Statement of the Problem.

The successful establishment of rootstocks from hardwood cuttings has always been an aim of propagation research at East Malling (Knight, 1926), and the past failure of growth substances to achieve it need not imply that their potential root-promoting power is absent in the fruit plant, for their effect with softwood cuttings has already been demonstrated (Pearse, 1939b). The investigation has now entered a new phase, more comprehensive than would hitherto have been profitable, which, as well as combining the different approaches already made, such as the consideration of external factors after planting, or growth substance treatments, takes into account the conditions obtaining during the growth of the plants from which the cuttings are taken. Thus much emphasis is now laid upon the source of the cutting, and a major aim of our recent and projected experiments is to assemble data showing how the regenerative behaviour of the hardwood cutting is influenced by a sequence of factors extending back to the development of its source plant.

The implications of this plan are wide, for it will be necessary to study in detail a range of rootstock varieties from comparable sources and then to co-ordinate and interpret the data. Into this scheme it is intended to incorporate systematic observations on the interaction of growth substance effects, for only then can the root promoting influence be fully assessed. Such a systematic approach tends to supplant the isolated experiment. This present account constitutes a link between earlier experiments and those now in progress, with brief mention of results in so far as they illustrate the progressive development of the technique of application of growth substances.

Experiments with Myrobalan B and Crab C Rootstocks.

Following a review in 1943 of the general position (Garner, 1944) it appeared that the first step in the analytical approach would be an intensive study of certain carefully selected rootstocks. The two chosen were Myrobalan B plum, one of the few rootstocks raised commercially from cuttings, and

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Crab C apple, a rootstock not particularly suited to the more usual methods of stooling and layering, and for which an effective propagation technique was required. The plum stock is definitely an "easy-rooter", the apple a "shy rooter", and thus these provide contrasting types for study; in addition, before the Crab C stock could be recommended for commercial propagation a successful method for dealing with it needed to be developed (Garner and Hatcher, 1948). It is not of course suggested that these two stocks are representative of two broad types, for rootstock behaviour is essentially an individual characteristic which vegetative reproduction seeks to preserve. For this reason the results of experiments with Myrobalan B and Crab C can be extended only by further work with other stocks. Ultimately, however, it is hoped that the underlying principles of regenerative behaviour in relation to rootstocks will be discovered and formulated.

The Growth Substance Approach.

In the analytical method envisaged the number of growth substance treatments necessarily had to be limited, and the selection of a standard growth substance was made. The experimental justification for this procedure is that, in comparing the root promoting power of various compounds, certain of them stand out in quite a general way. The original active synthetic compound, with which hetero-auxin was identified, is β-indolyl-acetic acid, but this substance is surpassed in many cases by β-indolyl-butyric acid and α-naphthalene-acetic acid. β-indolyl-butyric acid was chosen for this work because its action is associated with the formation of a more fibrous root system.

The selection of a standard growth substance, nevertheless, does not exclude the use of other compounds. In recent years a large number of substances, within broad structural groups, has been synthesized and any reported to have high root-promoting power will be tested on rootstock material.

Treatment of the Cutting.

Various methods have been described by Pearse (1939b) and Garner (1944). The solution method, widely used, employs dilute aqueous solutions of the growth substance, and depends for full effect on active uptake by the cutting over an extended period, usually of the order of twenty hours; maximum rooting response is found usually to fall within fairly narrow concentration limits. The alternative dust method utilizes relatively concentrated amounts of growth substance, but permits of immediate planting; this method is much less precise regarding optimal strength, a fact which is allied to a correspondingly lower degree of reliability, in turn relatable to such things as the texture of the inert powder carrier.

TABLE I.

RESPONSE OF HARDWOOD CUTTINGS OF ROOTSTOCKS TO TREATMENT WITH β-INDOLYL-BUTYRIC ACID.

	Myrobalan B Plum.		Crab C Apple.	
	Control.	5 p.p.m.	Control.	30 p.p.m.
Rooted and Established ..	320	293	19	87
Alive not Established ..	9	0	227	3
Dead	31	67	114	270
Total	360	360	360	360

The solution method, regarded as preferable for experimental work, was used in concentration trials to determine optimal strength for Myrobalan B and Crab C. It was found with the plum stock that while a strength of 5 p.p.m. (parts per million) had no pronounced effect on increasing the percentage of rooted cuttings, higher concentrations were somewhat deleterious. In fact this proved to be an interaction effect with planting temperature, and will be considered in a subsequent paper. The standard solution strength for Myrobalan B was therefore fixed at 5 p.p.m. For the apple stock a much higher concentration was found necessary to obtain optimal response, and 30 p.p.m. was adjudged the required standard strength. Again a planting temperature interaction with growth substance treatment appeared. As an illustration of the effect of applying the standard concentrations of 5 and 30 p.p.m. to the plum and apple rootstocks respectively, some results are given in the above table. The values inserted are actual numbers of cuttings, 360 being used for each main treatment.

Table I reveals several important differences between the two stocks. Most of the plum cuttings rooted without treatment, of the remainder a few were alive but not established at the end of the season after planting, while a number of cuttings died. Growth substance treatment, at 5 p.p.m., did not increase the number of rooted cuttings, in fact there was a slight depression, with no unestablished cuttings remaining alive. This table shows only the main treatment effects and it should be stated that the depressing effect on number rooting was confined to sub-treatments involving a period of warmth at planting.

Considering the apple cuttings it will be observed that without treatment very few cuttings rooted, about one third died, and about two-thirds, 227 out of 360 were still alive at the end of the growing season. Growth substance treatment at 30 p.p.m. had a definite stimulating effect on rooting, 87 cuttings becoming established. Of the remainder all died with the exception of three cuttings.

The results of this experiment show quite conclusively that the shy-rooting apple hardwood cutting is able to respond positively to the root-promoting action of a growth substance. In addition they demonstrate a characteristic effect of such treatment, namely the marked influence on the survival of the cuttings, which, failing to root after stimulation by the growth substance, succumb during the growing season, unlike many unstimulated cuttings, especially of apple, which survive.

The Concentrated Dip Method.

A further method of treating cuttings with a growth substance has been described by Hitchcock and Zimmerman (1939) in which the cutting base is dipped momentarily in a concentrated alcoholic solution of the active substance. This technique appeared to combine the respective advantages of the dust and solution methods, that of instantaneous treatment and reliability, and following exploratory experiments it has now largely been adopted in our investigations.

The aim again was to determine for the rootstock varieties the optimal concentration, but it was felt that statements in the literature could well act as a guide in deciding the standard strength for immediate use. For a wide variety of plants, for soft and hardwood cuttings, concentrations ranged from 1 mg. to 10 mg. of the growth substance per 1 c.c. of 50 per cent. ethyl alcohol, and in the 1945-46 season, therefore, a standard dip of 5 mg. β-indolyl-butyric acid per 1 c.c. 50 per cent. alcohol was used. This strength was found to be quite deleterious for Myrobalan B plum, and only moderately safe with Crab C apple. In 1946-47 the standard dip was lowered to 2 mg. per c.c. 50 per cent. alcohol, and in the present season, 1947-48, to $\frac{1}{2}$ mg. per c.c. 50 per cent. alcohol. This has been done on the basis of concentration trials, but as these are still in progress, their further discussion must be deferred.

It should be noted that the 1947-48 standard dip is beyond the lowest concentration of the range mentioned above, and that this, with other rather unexpected features of the results with rootstocks, has led to a more detailed examination of the dip technique, and particularly the nature of the solvent used. There is little doubt, however, that the dip method of treating the cuttings compares most favourably with the solution and dust methods. Furthermore, as the concentrations now being employed are relatively quite low for an instantaneous treatment—$\frac{1}{2}$ mg. per c.c. being equivalent to 500 p.p.m.—an objection to this technique on the score of the high cost of the growth substance has proved invalid. Incidentally, β-indolyl-butyric acid, our standard growth substance, happens to be still relatively expensive to synthesize, and it should be said that an equally effective substituted phenoxy acid would be preferred on account of its relative cheapness.

Discussion.

In this paper concerning the growth substance treatment of rootstock hardwood stem cuttings no direct reference is made to the mode of action of the growth substance, for this cannot be understood without considering the effects of other factors, particularly the source of the material used. Moreover, the analytical approach which is being made to the problem will demand the accumulation of experimental data over a period of years, and any general conclusions must be deferred. The criterion of positive response to growth substance treatment, namely an increase in the percentage of rooting, is likewise much too empirical for a complete understanding of growth substance action, particularly so in the case of a variety which may, even without stimulation, manifest high percentage rooting. Sufficient has been said, however, to indicate that even a shy-rooting stock such as an apple manifests a significant degree of response to treatment. This is a definite advance on the earlier position in this research ; and followed from the due regard paid to the physiological condition of the cutting at the time of its separation from the source plant.

Summary.

An account is given of the use made of synthetic growth substances in the analytical study of fruit tree rootstock propagation by the method of hardwood stem cuttings. The development in the use of standard growth substance treatments is described and also the substitution of a concentrated dip method for the older techniques of dust and solution treatment. The differential response of Myrobalan B plum and Crab C apple is illustrated, and the positive reaction of hardwood apple cuttings to growth substance treatment is for the first time established.

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INTENSIVE EXPERIMENTAL METHODS IN ABSCISSION STUDIES

By H. W. B. BARLOW*

Introduction.

The use of synthetic growth-substances to control the pre-harvest drop of apples and pears is now wide-spread, and several commercial sprays for this purpose are on the market. Experimental work on the subject (summarized up till 1945 by Vyvyan, 1946) and orchard experience show, however, that not all varieties respond equally to treatment, and that certain substances are more effective on some varieties than on others ; furthermore it has been considered that " June drop " is not susceptible to control by such substances as inhibit pre-harvest drop, though this view may need amending in the light of recent work (Vyvyan and Barlow, 1947 and 1948). Methods are therefore needed by which a number of compounds may be tested for their effectiveness in delaying abscission on several varieties at different stages of fruit development without employing large-scale field trials.

Gardner and Cooper (1943) worked with Coleus petioles for this purpose, but it seems essential to use for the test the actual fruit varieties in which control is desired, because of the apparent specificity of some compounds for certain varieties as already mentioned.

The actual mechanism of abscission and the manner in which it is either influenced by applied synthetic substances or naturally controlled by the plant, are matters imperfectly understood ; among other approaches to these problems a means is required of applying growth-substance quantitatively and in a definite position.

Techniques to meet these various needs are briefly described, and some experimental results are given to illustrate their use.

Methods for Estimating the Effectiveness of Growth-Substances in Delaying Abscission.

When the flower, fruit, or leaf-blade is cut off leaving the stalk attached to the plant, this stalk will absciss in a normal manner within a short period (6-10 days for flower or fruit pedicels of the apple varieties Cox's Orange Pippin and Bramley's Seedling). If such stalks are treated with an effective substance, however, abscission is delayed.

Vyvyan in 1946 devised a rapid method of applying growth-substances to defruited pedicels and this was employed in 1947 to test the effectiveness of twenty-six compounds in delaying the abscission of flower-stalks of Cox's and Bramley's.

In this technique each substance is made up at 20 p.p.m. in 50 per cent. ethyl alcohol and a drop is applied from a pipette to each pedicel ; the alcohol spreads over the surface and dries almost immediately. Alcohol alone seems to have no effect on the plant. At intervals after treatment the stalks are examined, a light standardized pressure being applied laterally to each stalk by means of a small spring which dislodges it if abscission has taken place. The average period for which the stalks persist (expressed as the geometric mean) is used as an index of effectiveness for the substance.

From the twenty-six compounds the most effective ones were again tested by the same technique but including two other concentrations. The results are shown in Table I, which compares the substances at each concentration.

The comparison of concentrations for each substance showed significant differences as follows :

α-(2-chlorophenoxy)-propionic acid—between all three concentrations on Cox, and between 10 and 40 p.p.m. on Bramley.

2,4-dichlorophenoxy-acetic acid—between 10 and 40 p.p.m. on Cox and between 10 p.p.m. and the two upper concentrations on Bramley. This is the only substance which seems to be more effective at a low than a high concentration and then only on Bramley.

Methyl-β-naphthoxy-acetate—between 10 and 40 p.p.m. on Cox, and between 40 p.p.m. and the two lower concentrations on Bramley.

2-methyl-4-chlorophenoxy-acetic acid—between 10 and 40 p.p.m. on Bramley.

α-(2,4-dichlorophenoxy)-propionic acid—between 40 p.p.m. and the two lower concentrations on both varieties.

Naphthalene acetamide—between 40 p.p.m. and the two lower concentrations on Bramley.

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Table I.

Persistence in Days of Defruited Pedicels Treated With Synthetic Growth Substances.

Variety.					
Cox's Orange Pippin.			Bramley's Seedling.		
10 p.p.m.	20 p.p.m.	40 p.p.m.	10 p.p.m.	20 p.p.m.	40 p.p.m.
b 12·82	*d* 12·11	*d* 20·03	*a* 46·44	*a* 26·70	*b* 26·12
c 9·70	*e* 11·06	*c* 15·15	*b* 16·73	*b* 23·53	*a* 23·68
d 9·27	*b* 10·66	*e* 13·50	*c* 10·53	*d* 10·10	*c* 16·63
f 9·25	*f* 10·25	*b* 13·08	*d* 8·86	*c* 10·09	*f* 14·00
e 9·09	*c* 9·52	*a* 10·87	*e* 6·97*	*f* 9·65	*e* 13·89
j 8·42*	*a* 8·84	*f* 10·65	*h* 6·82*	*j* 9·29	*d* 12·59
h 8·02*	*h* 8·61	*g* 8·79	*j* 6·67*	*e* 8·67	*h* 11·10
g 7·74*	*g* 8·19*	*j* 8·57*	*f* 6·42*	*h* 7·95	*g* 9·76
a 7·69*	*j* 7·69*	*h* 8·50*	*g* 5·79*	*g* 6·35*	*j* 9·36
Control 7·13			Control 5·65		

Key to substances:

a. 2,4-dichlorophenoxy-acetic acid.
b. 2-methyl-4-chlorophenoxy-acetic acid.
c. α-(2,4-dichlorophenoxy)-propionic acid.
d. α-(2-chlorophenoxy)-propionic acid.
e. Methyl-β-naphthoxy-acetate.
f. α-naphthalene-acetic acid. (NAA)
g. Naphthalene acetamide.
h. and *j*. Two samples of indolyl-butyric acid.

Notes. (i) Treatments bracketed together do not differ significantly.
(ii) Values marked * do not differ significantly from the controls.
(iii) The figures are corrected for five pedicels per spur in the Cox, and two per spur in the Bramley experiment.

•

It will be seen that the two varieties responded differently to some of the compounds, particularly to 2,4-dichlorophenoxy-acetic acid, which was the most effective for Bramley but among the relatively ineffective for Cox, while the reverse was true for α-(2-chlorophenoxy)-propionic acid. Also in general where there was any effect it was greater for Bramley than for Cox.

The great variability in the experimental material renders all but the largest differences uncertain, and as in any case this test method applies to an artificial condition of the tree, the results are checked by another small-scale testing technique. This consists of spraying an aqueous solution of the growth substance over a length of branch carrying 15 to 20 fruit, using a small spray-gun operated by air from a hand-pumped pressure cylinder. This spray-gun delivers liquid from a test-tube clipped on to it, and small quantities can be used efficiently ; in an experiment on Cox, the results of which are shown in Fig. 1, 10 c.c. were applied to branch units three to four feet long. The fruits remaining on the branch were counted initially and at intervals till harvest.

Four substances were used at concentrations of 1 and 4 p.p.m., applied on 4th July, 1947. To avoid confusion in the graphs one of the compounds has been omitted ; this is 2-methyl-4-chlorophenoxy-acetic acid, which at 1 p.p.m. behaved very like the control, while at 4 p.p.m. it was similar to, but not quite as effective as, NAA.

It will be seen that over this period the most effective material was NAA, which acted mainly on the " June drop ", the peak of which in this experiment was in late July ; thereafter treated and untreated fruit behaved similarly.

A Method for the Quantitative Application of Growth-substances to Plant Organs.

As has been mentioned, a technique was needed by which a known constant amount of growth-substance could be applied in a selected position. The alcoholic solution method was unsuitable as the liquid spread over an indefinite area of the plant surface, while agar blocks either dried up or were knocked off by rain. These difficulties were met by using a lanolin emulsion prepared according to Winklepleck and McClintock (1941) and making up NAA in this at 100, 10, 5, 2·5, 1·25 and 0·625 p.p.m. These pastes were applied by means of small glass syringes graduated to deliver 20 mg. of paste when the plunger was pushed from one mark to the next ; the small cylinder of paste thus

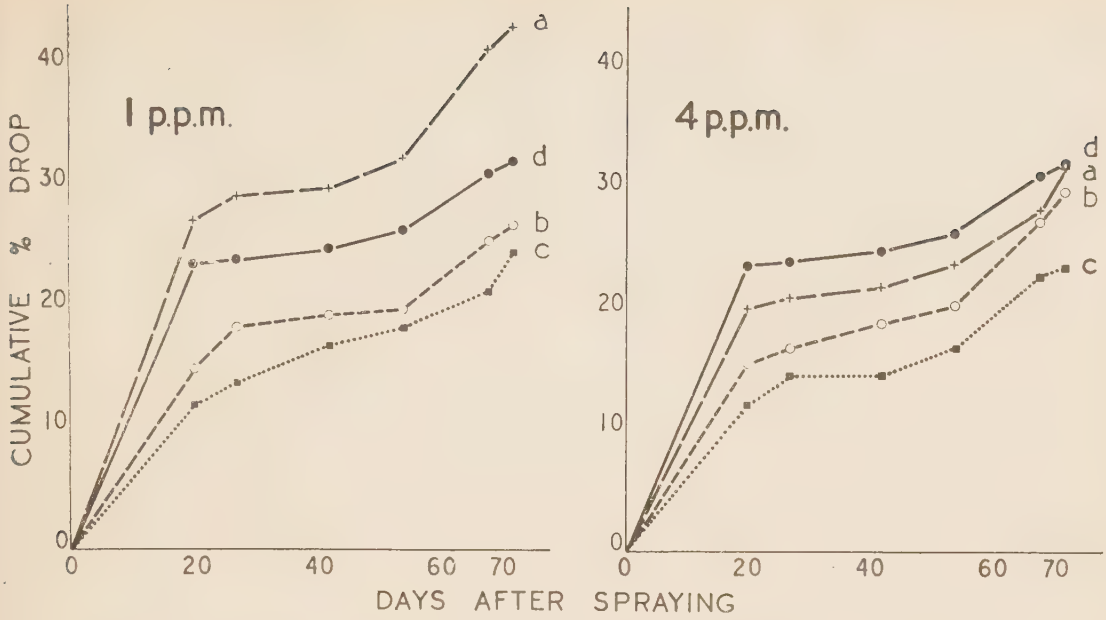

Fig. 1.

Cumulative percentage drop of Cox from 4th July, 1947 (day 0) till harvest on 16th September. Treatments were (*a*) 2,4-dichlorophenoxy-acetic acid ; (*b*) α-(2,4-dichlorophenoxy)-propionic acid ; (*c*) α-naphthalene-acetic acid ; (*d*) control, unsprayed.

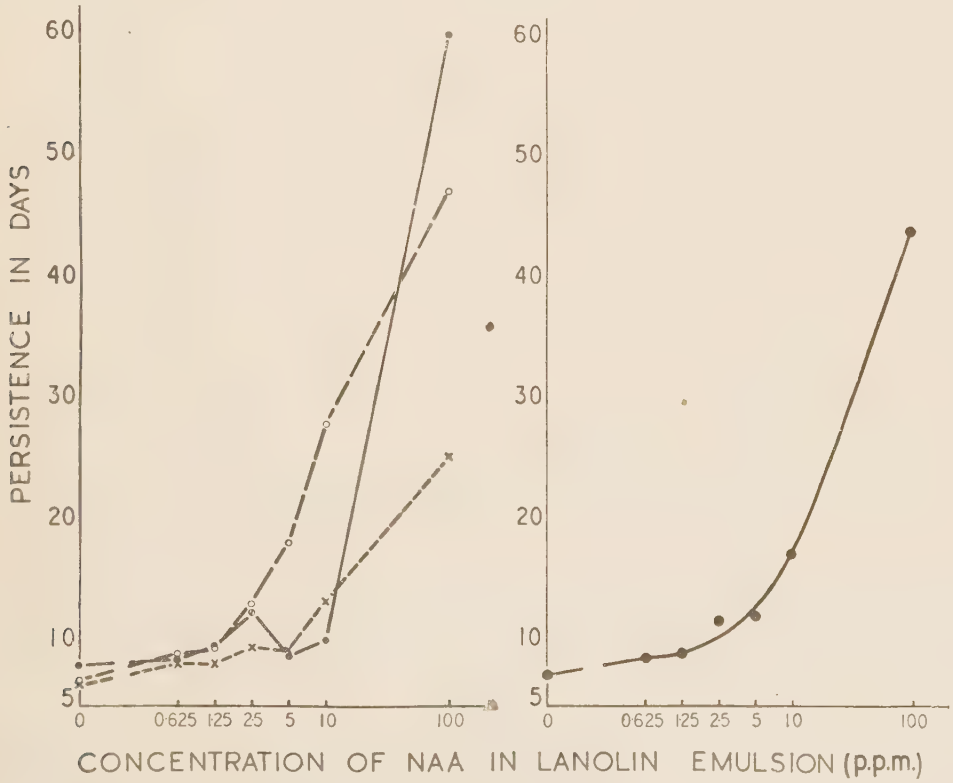

Fig. 2.

Relationship between concentration of NAA and persistence of Cox defruited pedicels. Left : results of three experiments ; right : smoothed mean of all three. The concentration is plotted on a logarithmic scale.

extruded was cut off with a scalpel and placed in the desired position, usually to the cut end of a defruited pedicel.

A few illustrations are given of the types of experiment for which the technique was employed.

A relationship was established between the concentration of NAA and the persistence of the pedicel; the threshold value was about 1 p.p.m. and the maximum effect had evidently not been reached at 100 p.p.m., as seen in Fig. 2.

An indication was obtained that this effect was one of concentration as such, rather than of the absolute amount of NAA applied per pedicel, but corroboration of the result is needed.

By applying the emulsion at the end of the defruited pedicel, over a small nick made at the abscission zone, and over a similar nick made on the spur 1-2 mm. below the abscission zone, it was shown that to be effective the growth-substance must arrive basipetally at the absciss layer (Table II).

TABLE II.

SITE OF APPLICATION OF NAA TO COX PEDICELS.

Mean persistence in days.

	p.p.m. NAA	
	0	10
On tip of pedicel	8·35	22·14
At abscission zone	8·34	25·36
On spur below abscission zone ..	9·16	9·17

Table III shows the large effect of pedicel length on its persistence when treated with NAA in lanolin emulsion, though untreated pedicels behaved similarly at all lengths.

TABLE III.

INFLUENCE OF PEDICEL LENGTH ON EFFECT OF NAA.

Mean persistence in days.

	Experiment A.		Experiment B.
	p.p.m. NAA.		
	0	10	10
Full length (1·5 cm.) ..	8·35	22·14	25·12
Half length	9·18	29·18	—
Quarter length	8·88	46·03	43·19

This result falls into line with those obtained by Gardner and Cooper (1943) with Coleus petioles.

Summary.

Methods are described for testing a number of growth-substances for their effectiveness in delaying abscission in apples, and a technique for the quantitative application of lanolin emulsion containing growth-substance. Some experimental results are given to illustrate these methods.

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BIOCHEMISTRY

PHYSIOLOGICAL EFFECTS OF MANGANESE

By B. D. BOLAS and G. B. PORTSMOUTH*

Introduction.

The effect of manganese on photosynthesis in the potato plant was investigated using a modification of the Sachs' half-leaf method, developed at East Malling. Using this method pairs of opposite leaflets are chosen and corresponding half-laminae sampled at dawn. The half-laminae remaining on the plant are then allowed to assimilate for several hours before being sampled. Both leaf areas and fresh and dry weights are determined at each sampling, thus enabling the increase in dry weight per unit area to be used as a measure of carbon assimilation. A means of correcting for changes in area during the assimilation period is also embodied in the method.

Manganese deficient plants were grown both in pots and in the field using the Bradbourne lake bed soil known to produce deficiency. For the purpose of an experiment twenty-four pairs of suitable leaflets were chosen and the manganese level in one leaflet of each pair was artificially raised four days beforehand. This was accomplished by means of the Roach leaf-stalk injection technique, a dilute solution of manganese sulphate being injected through the leaf stalk of the next leaflet below on one side only. The evening before an experiment the injected leaflets were examined for responses and twelve undamaged pairs selected and marked.

TABLE I.

CORRECTED DRY WEIGHT PER SQUARE CENTIMETRE (MILLIGRAMS)

Expt. No. and date. (1)	Plus Manganese. Mean morning. (2)	Plus Manganese. Mean evening. (3)	Plus Manganese. Apparent assimilation. (4)	Control. Mean morning. (5)	Control. Mean evening. (6)	Control. Apparent assimilation. (7)	Effect of Mn Diff. (4)-(7). (8)	Remarks (9)
1. 30.6.47	4·261 ±0·132	4·402 ±0·090	0·141 ±0·095 (3·868% ±2·285%)	4·116 ±0·125	4·463 ±0·117	0·348 ±0·095 (8·897% ±2·635%)	−0·207 ±0·085 (P<0·05)	Slight visual response.
2. 14.7.47	3·654 ±0·119	3·941 ±0·100	0·287 ±0·061	3·523 ±0·093	3·934 ±0·107	0·411 ±0·081	−0·125 ±0·129	Slight visual response.
3. 28.7.47	3·554 ±0·075	4·165 ±0·139	0·611 ±0·113	3·303 ±0·094	3·702 ±0·099	0·399 ±0·114	+0·212 ±0·128	Strong visual response. Control leaflets developed necrotic spots after injection.
4. 18.8.47	4·741 ±0·132	5·393 ±0·145	0·653 ±0·155	4·594 ±0·087	5·514 ±0·151	0·920 ±0·144	−0·268 ±0·172	No visual response.
5. 1.9.47	5·423 ±0·163	6·057 ±0·182	0·633 ±0·152	5·301 ±0·143	6·070 ±0·176	0·769 ±0·147	−0·136 ±0·234	V. slight visual response.
6. 15.9.47	4·977 ±0·201	5·455 ±0·161	0·478 ±0·110	4·899 ±0·167	5·530 ±0·214	0·631 ±0·100	−0·153 ±0·166	V. slight visual response.

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Results.

(1) **Assimilation.** In all, some six experiments were carried out, the first two on pot plants and the remaining four in the field. The duration of the assimilation period varied from $4\frac{1}{2}$ to over 7 hours depending on weather conditions. Data for the apparent assimilation recorded, showing the effect of manganese on photosynthesis in the potato plant, are given in Table I.

It will be seen that although the method has an accuracy of just over ± 2 per cent. there are no significant increases in assimilation as a result of manganese injection. In fact, the only case in which an increase was recorded was in Experiment 3, in which there was a very marked visual response together with a development of necrotic spots on the control leaflets subsequent to injection. The apparent increase, therefore, was obviously due to a decrease in the area of actively assimilating tissue of the control leaflets and not to an increase in the assimilation rate with manganese.

The general trend, rather, is a decrease with manganese and the only result statistically significant is in this direction.

(2) **Dry Weight per Unit Area.** The data in columns (2) and (5) of Table I, however, indicate that the dry weight/unit area of the injected leaflets at the beginning of an experiment is consistently higher than that of the control leaflets. The extent of this effect is shown in Table II below :

TABLE II.

MEAN INITIAL DRY WEIGHT PER SQUARE CENTIMETRE (MILLIGRAMS)

(1) Expt. No.	(2) Plus Mn morning.	(3) Control morning.	(4) Difference (2)-(3)	(5) Per cent. difference.
1.	4·261	4·116	+0·145	3·52
2.	3·654	3·523	+0·131	3·71
3.	3·554	3·303	+0·251	7·60
4.	4·741	4·594	+0·147	3·20
5.	5·423	5·301	+0·122	2·30
6.	4·977	4·899	+0·078	1·59
Mean	4·434	4·289	+0·146	3·65
S.E.			±0·023	±0·85
"t"			6·221	4·277
Value of "t" for P = 0·01			4·032	4·032

It will be seen that the effect is highly significant ($P < 0{\cdot}01$). This effect on the dry weight/unit area had been previously obtained by Bolas (1946) who presented it as evidence for an increased assimilation. The effect changes quite regularly throughout the season, reaching a maximum at the end of July, the time of Experiment 3. The interpretation of the effect is at present obscure and will receive attention.

(3) **Manganese Levels.** Estimations of the manganese content of all experimental half-leaflets have been carried out by a modification of the method adopted by Nicholas (1946) using tetramethyl-diaminodiphenylmethane. Data for the mean manganese contents found in all six experiments are given in Table III.

It will be seen that the manganese content of the experimental leaflets has been effectively raised by injection.

The differences between the proximal and distal halves of the injected leaflets themselves are what would be expected from the vascular anatomy.

It may be noted that the manganese levels in the control leaflets of Experiment 3 are markedly lower than any others.

TABLE III.

MEAN LEAF MANGANESE CONTENT IN PARTS PER MILLION ON DRY WEIGHT.

	Injected Leaflet.		Control Leaflet.	
Expt. No.	Proximal half-leaflet.	Distal half-leaflet.	Proximal half-leaflet.	Distal half-leaflet.
1.	258	89	29	30
2.	76	78	24	23
3.	86	20	6	6
4.	111	47	11	13
5.	101	52	14	14
6.	182	73	19	17

Summary.

A series of assimilation experiments on manganese deficient potato plants was carried out in the summer of 1947.

No increase in apparent photosynthesis was found to result from the injection of a dilute solution of manganese sulphate, but a significant increase in dry weight per unit area was obtained.

Chemical analyses showed that manganese levels in the experimental leaflets had been effectively raised by injection.

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PLANT PATHOLOGY

AN EXPERIMENT IN APPLYING UNDILUTED LIME-SULPHUR TO APPLE TREES

By M. H. MOORE

Increasing knowledge of pest and disease control in fruit had before the war shown the urgent necessity for greater speed in spraying operations, and the progress then being made in the development of suitable spray machinery in this country received great impetus under war-time conditions. Mobile machines are now available that deliver large volumes of spray rapidly at high pressure. Hence to-day one of the chief problems concerned with this kind of spraying is how best to provide and handle large quantities of water with the least waste of time ; some modern devices for meeting it make most pre-war mobile spraying seem grossly out of date.

The use of copious spray at high pressure has made it imperative to increase the dilution of fungicides if severe spray damage to foliage and fruit is to be avoided ; modern trends have therefore emphasized the disproportion in volume between the toxic part of the spray and the water used for its dispersal—the current problem arises more from the diluent than from what it carries.

This water problem might be greatly mitigated if dusting were a more reliable control measure than experience has shown it to be. Even so, dusting proved distinctly useful against Apple Scab in early experiments (Moore, 1934) and is practised by some growers, evidently with reasonably satisfactory results. Because its performance tended to be unreliable and to be conditioned largely by the weather, it was never regarded then as a serious competitor of spraying, but was recommended for use in appropriate circumstances as an adjunct to spraying, and is mostly in practice as such nowadays. It might profitably be reconsidered if desirable improvements in the retentive properties of dusts could be brought about, though there might still be difficulties in spraying against certain diseases and pests and dusting against others at short intervals.

If water as a diluent could satisfactorily be dispensed with, if only during the growing season when time presses most urgently, the conception of pest and disease control would doubtless undergo fundamental change.

Increasing attention is being given to the use of air for this purpose, and fogs of atomized liquid drops of concentrated insecticides and smokes of solid ones are already familiar in horticulture, though so far chiefly for use under glasshouse or other shelter. Outdoors, an artificial air draught is employed in at least one device for dispersing spray-fluid in the fruit plantation ; in this case, however, air does not replace water, but functions usefully as an aid to a normal method of applying dilute sprays, and may as such even enhance the water problem. The principle of using the air draught is, however, important, and capable of adaptation for atomized concentrates.

Air dispersal of atomized concentrates in the fruit plantation raises a fresh series of problems, some of which may not be foreseen. On the other hand, spraying problems are already recognized by experience and can mostly be overcome at a cost, yet the great advantages offered in prospect by atomization of concentrates make an investigation of its problems worthy of preliminary study. Moreover, there is as yet little evidence that much attention has been given to fungicides, and with at least apples and pears it is convenient to build a spring and summer spray programme around the fungicide schedule.

Experiment.

An attempt was made in 1947 solely, at this early stage, to determine how apple trees would react to an application of lime-sulphur used without water dilution. In prospect the undertaking appears ridiculous because the trends of the last twenty years or so have all been towards increasing the dilution of this spray to render it more generally safe. Wholesale spray damage was, in fact, anticipated, and because of that a series of dwarf-pyramid trees raised specifically for investigations on spray damage was chosen for the venture rather than valuable cropping trees in the plantation.

There were 22 Lane's Prince Albert and 25 Lord Derby on M.I. rootstock, planted as maidens in 1943-44, 50 Cox's Orange Pippin and 25 Worcester Pearmain on M.I., planted as maidens in 1941-42, and 22 Bramley's Seedling on M.II, planted as maidens in 1945-46. Five treatments were uniformly

distributed amongst them, *viz.* undiluted lime-sulphur* (1) sprayed (2) atomized: diluted (2½ per cent.) lime-sulphur (3) sprayed (4) atomized: controls (5) untreated. Diluted lime-sulphur was included as well as controls as an additional standard by which to judge results from the undiluted spray.

Treatments were applied on 26th June in hot, sunny weather with a light south-east breeze, the spray from a hand-operated solo sprayer and the fog from an ordinary paint-gun with an adjustable De Vilbiss nozzle attached by flexible hose to a compressor driven by a small petrol engine. This period, the beginning of normal "June-drop", was chosen because apple trees about that time are often specially sensitive to spray damage.

The atomizer nozzle was set to give a fairly wet mist and was kept rapidly moving so as to provide only momentary dampness to leaves and fruit; the deposit dried almost at once. A volume of thirty-seven fluid ounces of the 2½ per cent. dilution was atomized on to thirty trees, and, on a further thirty, sixteen fluid ounces of the undiluted lime-sulphur, which proved very viscous and sticky to handle. Eleven pints of this concentrate were tediously and with effort hand-pumped on to twenty-four trees, and fourteen pints of the 2½ per cent. dilution on to thirty trees. The following day there was an unusually severe thunderstorm with drenching rain.

Summary of Observations.

The trees sprayed with the concentrate dried very slowly, and then showed a heavy, white deposit very conspicuous from a distance (Fig. 1, 2, 3). Trees that had received atomized spray showed little deposit (Fig. 1, 3) except under a lens.

7th July. Trees of all varieties sprayed with the concentrate showed scorch of the oldest leaves, usually starting from the margins and varying from moderate to severe, and often accompanied by up-curling. The youngest leaves on the top few inches of extension growths had crimped, scorched edges of various shades of red. A very obvious and consistent observation was a general lack of reaction by the leaves in the central area of these extension growths, especially where the trees were growing well; though very heavily coated with whitish spray deposit on both upper and lower surfaces, they were practically free from any kind of scorch, and seemed quite normal (Fig. 2). There was no drop even of severely scorched leaves.

Lane's showed suffused browning or reddening of many of the oldest leaves, especially the undersides, and slight sickly pallor of the rest of the foliage, where sprayed with the 2½ per cent. dilution; those that received the atomized concentrate showed a suggestion of general pallor, but nothing more.

Apart from the sprayed concentrate, therefore, the treatments seemed to have had no adverse effect on any variety except Lane's under the conditions of this experiment. Observations were made subsequently from time to time, and, except for some intensifying of the scorching already observed, accompanied by the dropping of a few of the oldest and most severely scorched leaves, no further host reaction developed.

8th September. Where sprayed with the concentrate, some of the fruits of all varieties, and especially Lord Derby, showed very localized blackening around some lenticels at the calyx end (Fig. 3). In addition, some of the Lane's fruits showed a shallow, suffused, reddish-brown patch like sun-scald on the skin facing south; this was a distinct disfigurement on some half-dozen fruits. All fruits as well as the trees still bore a thick spray deposit, and a few fruits had dropped evidently as a result of spraying, though the response was very delayed. A trace of the darkened lenticels was observed also on a few Lord Derby fruits treated with atomized concentrate.

There was a very good crop on most trees except Bramley's, which were younger; it had clearly not been affected by any treatment except the sprayed concentrate as stated.

Discussion.

The excessive damage expected from using undiluted lime-sulphur did not occur, for even when this was applied as a spray—an exceedingly drastic measure— the resulting damage to foliage, virtually confined to the oldest and youngest leaves, was really little more than has sometimes followed from using dilutions of this spray. No suggestion is, of course, implied here that the concentrate could ever be used commercially in ordinary spray form; it was included in this trial to complete the series and so indicate whether any damage caused was attributable more to the concentrate as such or to the method of its application. Evidently, though both were concerned, the heavier application was the more important factor. The atomized deposit dried at once, and the only semblance of damage was negligible pallor of Lane's foliage and a trace of discoloured lenticels on Lord Derby; both were very slight indeed. It is surprising that the 2½ per cent. dilution applied in midsummer as a spray did no more than slightly damage Lane's trees; it would be expected to scorch most varieties severely at that

* S.G. 1·3, 25 per cent. w/v. polysulphide S.

Fig. 1.

Lord Derby twenty-seven days after treatment. Sprayed (left) and atomized (right) with undiluted lime-sulphur. Sprayed Lane's in background (right).

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ENTOMOLOGY

NOTES ON THE INSECT FAUNA OF SPRAYED AND UNSPRAYED APPLE ORCHARDS

By A. M. MASSEE

Since the introduction of the new synthetic insecticides, particularly DDT and benzene hexachloride, renewed interest has been aroused regarding their effect, if any, upon beneficial insects.

Nearly twenty years ago the writer collected some data on the effect of a tar oil wash upon the fauna of the apple orchard and, since this subject is once more the concern of both investigator and the grower, it seems worthwhile recording the data obtained at that time.

The effect of DDT and of benzene hexachloride upon the fauna of the apple is being studied in the field and the data will be published separately in due course.

Unsprayed Orchard : East Malling.

An orchard consisting of one acre of standard trees, containing a mixture of closely planted varieties, including Lord Derby and Bramley's Seedling, was interplanted with Cobnut bushes.

The apple trees in this orchard had never been sprayed, but the nut bushes occasionally received an arsenical insecticide, which was applied with a hand machine to reduce caterpillar attack.

Sprayed Orchard : East Malling.

A well-kept orchard consisting of standard Lord Derby and Bramley's Seedling actually surrounded the unsprayed acre, being separated only by a right of way to the east side of the trees.

These trees were sprayed with a tar oil wash (Carbo Krimp) at 8 per cent. each December from 1927-31 inclusive. In addition the orchard was sprayed with the routine pre- and post-blossom insecticides and fungicides used in those days. The wash was applied by means of a portable machine, with a pressure of 300 lb. per square inch. The sprays were thoroughly applied under the supervision of the grower.

Records Obtained.

It was decided to collect a sample of the insects present on the sprayed and unsprayed trees of Lord Derby and Bramley's Seedling during the flowering period of the spring of 1931. The first records were obtained on 8th May when the first blossoms of Bramley's Seedling were opening and were continued each day until petal fall, some three weeks later. Full blossom was on 12th May.

Six trees each from the sprayed and unsprayed orchards were selected every morning and the insects were tapped from the trees into a Bignell Beating Tray and were speedily transferred to 3 in. by 1 in. glass tubes. The captures were examined later in the day. Since it was realized that many of the insects would fly readily on warm, sunny days, the actual collection was made from 7 a.m. to 8 a.m. whilst many species were still in the sluggish state. Each of the trees selected was tapped for a period of five minutes, at a height of about six feet from ground level, each aspect of the tree being visited.

It was not possible in the time available to obtain actual numbers of each species present, but for convenience they were divided into four categories as follows :

A — abundant
C — common.
UC — uncommon
S — scarce.

Fifty different species were recorded from the unsprayed and sprayed orchards, of which forty-five were collected from the former and twenty-one from the latter. Five species occurred on the sprayed trees which were not recorded from the unsprayed orchard. These species, however, were of no special significance.

The most striking difference between the fauna of the two orchards was the almost complete absence of Hemiptera in the sprayed orchard ; the one exception being the Apple Capsid Bug, which has since proved to be the major pest of the orchard until it was controlled by DDT some sixteen years

later. The likely explanation for the absence of Hemiptera is as follows. Many of the species recorded hibernate on the tree, under loose bark, etc.; these are destroyed when the winter wash is applied, hence their absence in the spring months. It is probable that later in the season several species of Anthocorids, for example, would return to the sprayed orchard when the second generation appears in late summer. This is known to occur regularly in some sprayed orchards, particularly those adjoining woods and spinneys.

TABLE I.

INSECTS COLLECTED FROM LORD DERBY AND BRAMLEY'S SEEDLING APPLE ORCHARD DURING THE BLOSSOM PERIOD 1931.

Unsprayed Trees.

Category.	*Scientific Name.*	*Popular Name.*
	COLEOPTERA.	BEETLES.
UC	*Phyllobius oblongus* L.	Brown Leaf Weevil.
UC	*Phyllobius argentatus* L,	Silver-green Leaf Weevil.
C	*Phyllobius pyri* L.	Common Leaf Weevil.
UC	*Polydrosus cervinus* L.	Leaf Weevil.
S	*Tetrops praeusta* L.	Little Longicorn.
UC	*Byturus tomentosus* F.	Raspberry Beetle.
C	*Anthonomus pomorum* (L.) Curt.	Apple Blossom Weevil.
S.	*Magdalis ruficornis* L.	—
C	*Cantharis nigricans* Ml.	—
UC	*Rhagonycha limbata* Th.	—
UC	*Dolopius marginatus* L.	—
UC	*Athous vittatus* F.	—
S	*Adalia 10-punctata* L.	Ten Spot Lady Bird Beetle.
C	*Adalia bipunctata* L.	Two Spot Lady Bird Beetle.
C	*Coccinella 7-punctata* L.	Seven Spot Lady Bird Beetle.
S	*Anaspis humeralis* F.	—
C	*Enicmus transversus* Ol.	—
C	*Meligethes aenus* F.	Blossom Beetles.
C	*Meligethes picipes* St.	
C	*Meligethes viridescens* F.	
C	*Meligethes erythropus* Gy.	
S	*Meligethes lugubris* St. var. *gagatinus* Er.	
C	*Meligethes brunnicornis* St.	
UC	*Atomaria linearis* S.	Pygmy Mangel Beetle.
UC	*Micrambe vini* Pz.	—
UC	*Corticaria elongata* Gy.	—
UC	*Corticarina gibbosa* Hb.	—
UC	*Anthobium torquatum* Mm.	—
	HEMIPTERA.	BUGS.
S	*Anthocoris confusus* Reut.	Anthocorid Bugs
S	*Anthocoris nemoralsis* Fab.	
C	*Anthocoris nemorum* L.	
C	*Orius majusculus* Reut.	
C	*Orius minutus* L.	
C	*Psyllia mali* Schr.	Apple Sucker.
C	*Sappaphis plantaginea* Pass.	Rosy Apple Aphid.
C	*Rhopalosiphum insertum* Wlk.	Oat-apple Aphid.
A	*Aphis pomi* de Geer.	Green Apple Aphid.
C	*Lepidosaphes ulmi* L.	Mussel Scale.
	LEPIDOPTERA.	MOTHS.
A	*Operophtera brumata* L.	Winter Moth.
C	*Erannis aescularia* Schiff.	March Moth.
C	*Hybernia defoliaria* Clerck	Mottled Umber Moth.
C	*Chloroclystis rectangulata* L.	Green Pug Moth.
UC	*Cacoecia podana* Scop.	Tortrix Moth.
	HYMENOPTERA.	SAWFLIES.
C	*Hoplocampa testudinea* Klug	Apple Sawfly.
	ACARINA.	MITES.
UC	*Allothrombium fuliginosum* Herm.	Red Velvet Mite.

Table II.

Insects Collected From Lord Derby and Bramley's Seedling Apple Orchard During the Blossom Period, 1931.

Sprayed Trees.

Category.	*Scientific Name.*	*Popular Name.*
	Coleoptera.	Beetles.
UC	*Phyllobius oblongus* L.	Brown Leaf Weevil.
UC	*Phyllobius argentatus* L.	Silver-green Leaf Weevil.
C	*Phyllobius pyri* L.	Common Leaf Weevil.
UC	*Polydrosus cervinus* L.	Leaf Weevil.
S	*Tetrops praeusta* L.	Little Longicorn.
UC	*Byturus tomentosus* F.	Raspberry Beetle.
C	*Anthonomus pomorum* (L.) Curt.	Apple Blossom Weevil.
UC	*Rhagonycha limbata* Th.	—
C	*Athous vittatus* F.	—
S	*Anaspis humeralis* F.	—
S	*Corticarina gibbosa* Hb.	—
S	*Psylliodes attenuata* Koch.	Hop Flea Beetle.
S	*Anaspis rufilabris* Gy.	—
S	*Grammoptera ruficornis* F.	—
	Hemiptera.	Bugs.
UC	*Plesiocoris rugicollis* Fall.	Apple Capsid Bug.
	Lepidoptera.	Moths.
A	*Operophtera brumata* L.	Winter Moth.
C	*Erannis aescularia* Schiff.	March Moth.
S	*Chloroclystis rectangulata* L.	Green Pug Moth.
S	*Cacoecia podana* Scop.	Tortrix Moth.
	Hymenoptera.	Sawflies.
C	*Hoplocampa testudinea* Klug.	Apple Sawfly.
	Acarina.	Mites.
UC	*Metatetranychus ulmi* Koch.	Fruit Tree Red Spider.

Another very interesting record from the sprayed orchard is the Fruit Tree Red Spider. In 1931 it was regarded as uncommon, but it must be noted that it has persisted in the orchard ever since. This mite was not recorded in the unsprayed orchard.

It will be noted that sixteen species occur in both lists. Of these the Leaf Weevils, the Raspberry Beetle, the Apple Blossom Weevil, a few Longhorn beetles and click beetles are predominant. Included also are the invaluable pollinating beetles. It is curious, however, that the Coleopterous genus *Meligethes* is not listed in the fauna of the sprayed orchard.

Another interesting record from the unsprayed orchard is the occurrence of the stately Red Velvet Mite, a beneficial species which is rapidly disappearing from the well-kept orchard.

It is realized that the list is far from being complete. The Diptera and Hymenoptera were not recorded because of the difficulty of obtaining accurate counts.

A detailed study of the fauna of sprayed and unsprayed orchards would provide a very fascinating piece of involved research work, and would provide invaluable information on this aspect of the economy of the orchard.

Summary.

A brief account is given of the fauna of sprayed and unsprayed orchards. Forty-five species were recorded from the unsprayed trees and twenty-one from the sprayed orchard.

The important species recorded were the Apple Capsid Bug and the Fruit Tree Red Spider from the sprayed trees; neither of these harmful species being found on the unsprayed trees. Several beneficial species found in the untreated orchard were absent from the sprayed one.

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1947

By A. M. MASSEE

1. Strawberry Blossom Weevil (*Anthonomus rubi* Hb.).

The Strawberry Blossom Weevil often causes considerable harm to strawberry plants by cutting the stems of the developing fruit trusses and leaves, thereby reducing the crop very considerably.

Fortunately this pest can be controlled efficiently by applying a DDT dust to the plants (See Annual Report for the year 1946). To be certain of control, however, the DDT dust must be applied at the correct time, namely, when the weevils first appear on the plants and start causing injury.

To help growers judge the timing of the dusts correctly, they are reminded that the adult weevils emerge from hibernation in the spring, and may be found on several wild host plants before infesting the strawberry fields.

At East Malling large numbers of these weevils were noted in the flower heads of dandelion, anemone and coltsfoot during the weekend of 20th April and at this period there was no trace of the weevils on cultivated strawberry plants. Their presence in the flower heads served as a reminder that within a few days they would fly into the cultivated strawberry fields, thus warning the grower to be prepared to destroy them should the necessity arise.

2. Ant Beetle (*Thanasimus formicarius* L.).

The Ant Beetle is marked with red, white and dark blue on the head, thorax and elytron, and frequently occurs in old apple and pear orchards, where it lives under the bark of the old trees.

These beetles were present in large numbers in an old orchard at Teston, Kent, in April. The insect was kept under observation and the active larvae were noted to be predaceous upon two species of wood boring beetles infesting the trees. The species concerned were the Large Fruit Bark Beetle (*Scolytus mali* Bht.) and the Fruit Bark Beetle (*S. rugulosus* Ratz.). Both these woodboring beetles were abundant, providing ample food for the larvae of the predaceous species.

This is but another example of a predaceous beetle, which normally attacks woodboring beetles infesting conifers, becoming the fruitgrowers' friend ; but its presence in a well-kept orchard would be very improbable.

3. Nut Leaf Roller (*Byctiscus betulae* L.).

This very handsome metallic, green weevil, with its typical snout is one of the gems of British coleoptera. In nature it occurs in woodlands, and its host plant is hazel. The condition most suitable to this insect is the two and three-year-old hazel found in a recently cut-down wood or copse. Both the adult and larval stages feed on the plant, the latter stage producing a characteristic leaf roll into the form of a cigar, and the female lays her eggs within this habitation.

Darenth Wood, Kent, would appear to be its headquarters in South-East England, but it occurs locally throughout the Southern Counties. It also occurs not uncommonly in cultivated nut plats in Kent and was noted in several districts in May of this year. It was prevalent at Kingsdown, near Wrotham, Kent, where the characteristic leaf rolling indicated it was established in that particular nut plat. It was found also at East Malling and Marden, Kent, but was not plentiful enough to cause injury to the bushes.

A metallic, blue variety occurs with the type form, which is even more beautiful than the green form, if that is possible.

4. Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.).

The Apple Blossom Weevil is no longer an economic pest of apple, where control measures have been carried out efficiently, using the synthetic insecticide DDT. It still remains, however, in unsprayed orchards, in gardens and on crab apples growing in the hedgerows and woods.

In addition it was more numerous on pear trees than formerly and was reported by several growers during the spring months. It has been noted on pear trees for many years and has been referred to in publications issued by this Station, but the infestation was certainly a phenomenal one in 1947.

The adult weevils puncture and feed upon the developing buds during the latter part of March, in April and May, causing the buds to exude a sticky substance, which often disfigures the buds and shoots of some varieties of pear. This type of injury is very noticeable on pears growing on walls.

If this weevil is prevalent on pear in future years, it can be controlled very efficiently by the application of a DDT dust or wet apray as recommended for apples ; the time of application being the " bud burst " stage as for apples. If preferred a 0·1 per cent. DDT wettable powder can be added to the 5 per cent. tar oil wash which should be applied in late February or early March.

5. *Polydrosus sericeus* Sl.

Brief reference was made to this iridescent, green leaf weevil in these notes in 1945. Since that time it has steadily increased on top and soft fruits at East Malling and is now regarded as a locally common insect.

During May and early June it was present in considerable numbers on apple, plum and cherry. In addition it was plentiful on strawberry and, although the adult beetles were feeding on the foliage, the injury was not serious.

This is yet another interesting example of an insect changing its habits and attaching itself to cultivated fruits. In nature this weevil, which is considered a local and uncommon species, occurs on shrubs and trees, and the writer has found it on oak, hazel and willow, in woods, during the spring months.

It will be recalled that the Apple Fruit Rhynchites (*Rhynchites aequatus* L.) was first recorded on apple in this country by Mr. G. Fox Wilson of Wisley in 1928, and a little later by myself at Swanley on Fearn's Pippin. It is now regarded as one of the more important apple pests in Kent and other fruitgrowing districts.

If the Green Leaf Weevil (*P. sericeus* Sl.) persists on top and soft fruits and establishes itself, it may well prove to be one of the more important leaf eating species on fruit.

It is significant that when Dr. Gerard van Rossem, Wageningen, Holland, visited this Research Station last summer, he stated that *P. sericeus* Sl. was also beginning to establish itself on strawberry in Holland. It would seem, therefore, that this species of weevil is adapting itself to strawberry over a wide area. A most interesting and remarkable fact. The true explanation of this phenomenon would be welcome.

6. Silver-Green Leaf Weevil (*Phyllobius argentatus* L.).

The Silver-green Leaf Weevil is now recognized as being the most abundant leaf-eating species associated with top and soft fruits. It is, therefore, interesting to record it in considerable numbers in a nut plat at Teston, Kent. The adult weevil feeds on the tender leaves in May and early June and when present in large numbers may considerably reduce the vigour of the bushes. The developing nutlets are not attacked, thus the damage may be regarded as secondary.

The weevil was not noted in the same locality the year previously.

7. Nut Bud Tortrix (*Eucosma penkleriana* Fisch *v.* Rösl.).

Although the Nut Bud Tortrix has not been considered an important nut insect in the past, it was noted causing considerable injury to three nut plats in 1946 and 1947. Reports of damage were also sent in from Barming, Kingsdown and Teston, Kent.

This small Tortrix moth is red-brown, almost liver coloured ; basal patch deeper red-brown ; the dorsal area is the palest portion of the wing and often presents a conspicuous white square patch, which may, however, sometimes be a reddish colour ; hind wings smoky brown ; wing expanse $\frac{1}{2}$ inch.

The moth is on the wing in June and July and deposits her eggs on the leaves and shoots of nut and wild hazel.

The larva hatches out in late October and November and feeds on the catkins and buds ; and in the spring on the leaves. The larva is fully fed by May and then falls to the ground and turns into a chrysalis. The larva also feeds on oak.

The infested buds are hollowed out by the middle of April, then develop abnormally and eventually drop out. When the caterpillars are present in large numbers the damage may be very considerable.

Control measures have not yet been worked out, but it is probable that a DDT dust (5 per cent.) applied during October may prove efficient, since the minute larva hatches out at this period of the year.

This insect would present an ideal piece of research to the young entomological student wishing to study a Lepidopterous insect of economic importance.

8. Scarcity of Caterpillars of Winter Moth Group.

Fluctuations among insect populations are well known and fruit pests are not excepted. In some seasons serious outbreaks of aphides and caterpillars occur, in other years the infestations are negligible.

The spring of 1947 proved exceptional on account of the absence of caterpillars of the Winter Moth Group on top and soft fruits in Kent. For example, large areas of cherry, frequently heavily infested by various species of caterpillar, were almost entirely free and spraying operations against them proved unnecessary in many orchards.

Plums and apples also escaped the ravages of caterpillar infestations. A thirty-acre plum orchard in North Kent, which is very heavily infested with caterpillar every year, also remained free from attack.

Some growers have stated that the absence of caterpillar may be associated with the very cold spell experienced in February and March. This is not so, however, since the lack of caterpillar in the spring of 1947 is correlated with the low populations of Winter Moth and other species the previous autumn.

9. Small Ermine Moth (*Hyponomeuta malinellus* F.).

Twenty-five years ago it was not unusual to find the silken tents or nests of the Ermine Moth in apple orchards, particularly in the North Kent district. To-day one rarely finds this insect in cultivated fruit.

It is, therefore, noteworthy to record its presence in several orchards in the Maidstone district in June. The small spotted caterpillars live in colonies in very conspicuous silken tents or nests.

The general absence of this insect amongst cultivated fruit these days may be accounted for by the use of modern spraying equipment, and the routine applications of tar oil wash and of arsenical sprays in the spring.

10. Cherry Fruit Moth (*Argyresthia nitidella* Fab.).

The Cherry Fruit Moth still persists in many cherry orchards in various parts of Kent. This is unfortunate since it is well known that a thorough application of tar oil wash will largely eradicate this pest.

The reason why it still persists may be because most cherry trees are difficult to spray properly ; more especially the old, established orchards containing very large unwieldy trees. Infestations were noted at Chatham, Chartham, Gillingham and at Kingsdown. In each instance the orchards were old and neglected and badly sprayed.

Some larvae collected from the trees at Gillingham were fully fed by 5th July and went down into the soil to pupate.

11. Nutmeg Moth (*Mamestra trifolii* Rott.).

A most unusual kind of fruit injury was reported from Teynham, Kent, during the third week of September. The grower noticed many Laxton apples with pieces eaten out of them when still hanging on the trees. At first the damage was thought to be the work of birds, mainly Jays and Magpies. A number of birds were shot and their crops examined and were found to contain remains of larvae of the Nutmeg Moth.

A closer examination of the attacked orchards showed that the caterpillars of the Nutmeg Moth, which normally feed on Fat Hen, *Chenopodium album* L. had migrated from their normal host plant to the apple trees above, and fed on the growing apples.

The explanation for the change of diet was as follows. The grower ordered the Fat Hen to be cut down under the apple trees to clear up the orchards before fruit picking started. As soon as the weeds began to wilt the caterpillars moved off and fed on the apples. The damage proved very considerable and a typical example of injury from the Teynham orchard is depicted in Fig. 1.

Similar damage was reported from other fruit farms in East Kent where the Fat Hen had been cut down prior to picking, but the fruits at Teynham suffered more damage than elsewhere.

The Nutmeg Moth was also common in many other parts of Kent, including East Malling, but no damage was reported to the fruits.

The Nutmeg Moth is considered a local species, usually being associated with coastal districts. In 1947, however, it was abundant throughout Kent, especially in the eastern part of the county.

The caterpillar is green with a darker central and two whitish lines on the back ; the outer line being ornamented with black marks. A brown form of the larva occurs not uncommonly. It is a typical Noctuid caterpillar closely allied to the Cabbage caterpillar.

12. Scarcity of the Apple Capsid Bug.

The Apple Capsid Bug has rightly been regarded as the major apple pest for the past twenty years or so. It is, therefore, extremely encouraging to note that many Kentish orchards were completely free from this pest in 1947.

The reason for the disappearance of the Apple Capsid Bug is quite clear. The new synthetic insecticide DDT is the complete answer to the Apple Capsid problem, when applied at the right time and at the correct strength.

The DDT should be applied at the " green cluster " stage of bud development. A 0·1 per cent. DDT wash (5 lb. of 20 per cent. wettable powder per 100 gallons) can be used, and it should be added to the pre-blossom lime-sulphur scab spray. Only one application is necessary and if applied thoroughly complete control of the Apple Capsid Bug will be obtained.

13. Apple Sucker (*Psyllia mali* Schr.).

The Apple Sucker is no longer regarded as an economic insect in commercial fruit plantations, but it still persists to some degree where DNC is used each year and, of course, it is prevalent on unsprayed trees in gardens.

A serious infestation was noted in an orchard of Newton Wonder and Bramley's Seedling at Lingfield during the last week of May. The trees were sprayed with 7½ per cent. tar oil wash in early January. The spraying equipment used was quite modern and the application was said to be very thorough.

The insect was present on the trees in the egg state when the spray was applied and it can only be assumed that the particular spray used was not toxic to the eggs.

Many similar examples of spray applications failing to control certain pests occur every year and in most cases the explanation would be quite simple if full facts were known.

14. Absence of Hop-Damson Aphid and other Species in Kent.

Reference has been made to the scarcity of caterpillars of the Winter Moth Group in the spring months. The Hop-Damson Aphid, usually a very prevalent insect in the Kentish hop gardens in late May and June, was also uncommon and it did not occur in many gardens until quite late in the season.

It was common on damson and sloe during the spring months, but for some unknown reason did not migrate to the hop plant during the last week of May, as is its usual custom.

However, it did migrate to hop during the latter part of July and in August and in some gardens a late application of nicotine powder proved necessary to keep the aphid in check.

Late infestations of the Hop-Damson Aphid sometimes cause considerable injury, since the colonies establish themselves in the developing hop cones and check their growth.

The Strawberry Aphid was also almost entirely absent from cultivated strawberry during the spring and summer months, but some colonies were starting to build up on the plant in the autumn.

The absence of this species may be accounted for by the severe weather conditions prevailing in February and March. The aphid overwinters on the plant in the active state and doubtless the majority were killed off by the very severe frosts and low temperatures. The same phenomenon happened after the severe winter of 1939-40.

Many other species of fruit aphides were also less common than usual in the spring of this year, amongst them being the Green Apple Aphid, *Aphis pomi* De Geer.

15. Nut Aphid (*Corylobium avellanae* Schr.).

The Nut Aphid, a species closely allied to the Strawberry Aphid, is frequently abundant on cultivated Cob and Filbert nuts.

It was more plentiful on Cob nuts at Barming, Ightham, Kingsdown, Wateringbury and Teston than for many years and its effect on the growth of the bushes was considerable.

It overwinters on the bushes in the egg state. The aphids hatch in late April and May and swarm over the leaves and leaf stalks. In June most of the aphids move on to the developing nutlets, form little colonies or groups tightly packed together and feed on the nuts. During wet, cold weather they shelter within the sheath of the nutlet. In July these colonies disperse and the aphids return to the leaves. When severe infestations occur the bushes are sticky with honeydew.

The importance of this Aphid in relation to the economy of the host is not understood, but it may well be associated with other important diseases of nut.

16. Plum Leaf Hoppers.

No less than nineteen species of Leaf Hoppers have been recorded on cultivated plum and damson. Of these *Typhlocyba froggatti* Baker and *Erythroneura pruni* Edwards are probably the commonest species in Kent and both are abundant in the Maidstone district.

The immature leaf hoppers hatch out in late May and in June from eggs laid in the stems and trunks of the trees the previous summer. The hoppers feed on the foliage causing a distinct mottling or peppering of the upper surface. They feed also on the developing fruitlets producing a characteristic russeting which may be very pronounced on some varieties. The varieties most subject to fruit russeting are Denniston's Superb Gage and Oullin's Golden Gage. Czar is also affected but to a lesser degree.

Plum fruit russeting has been noted for many years, but the cause of the injury was not established. Many growers have thought this russeting to be the result of the fruits rubbing together or against a branch in the wind. It was not until fruits bearing russet marks were noted, which could not have been caused by rubbing, that leaf hoppers were suspected and found to be the cause. Shoots bearing young fruitlets were bagged in with muslin and leaf hoppers were placed inside the bags. In every case the characteristic russeting mentioned above was produced. The fruits bagged in without leaf hoppers did not russet. It is probable that several species of leaf hoppers cause a similar type of russet on the fruits, but the only species used in this empirical investigation was *Typhlocyba froggatti* Baker.

17. Anthocorid Bug (*Anthocoris nemorum L.*).

It is interesting to record very large numbers of Anthocorid Bugs on Myrobalan plums growing at the Research Station during the third week of April. The trees were in flower at the time and the adult bugs were very active on sunny days. They were also prevalent on sloe at the same period.

Their presence in such large numbers is interesting for two reasons. First it showed they escaped the very low temperatures of February and March ; second Myrobalan plums are not sprayed owing to their susceptibility to most of the routine washes used to-day. The fact that the trees were not sprayed accounted for the Anthocorid bugs remaining on the trees all the year round hence the high population in the spring. In sprayed orchards these Anthocorid bugs are absent in the spring months and do not return to the fruit trees until the new generation appears in the autumn.

Both tar oil washes and the new synthetic insecticide DDT are toxic to these beneficial bugs and must be used with discretion.

18. Hop Red Spider (*Tetranychus urticae* Koch).

In common with Fruit Tree Red Spider the Hop Red Spider (a distinct species) was prevalent throughout the Kentish hop gardens in the summer months. The mite populations started building up in May and June and by August many gardens were severely damaged by the mites. Serious outbreaks were noted in East Kent, Marden, and indeed all the hop growing areas of the county. The infestations were so serious in some gardens that the crops were completely ruined.

During the latter part of September and in October the overwintering red female form of the mite went into hibernation choosing such places as cracks in the hop poles, in the strings left on the wire and even in between the strands of wire used in the gardens. Another favourite situation in which they hibernate is under clods of earth and stones in high well-drained soil.

It is as well to remember that the overwintering mites come out of hibernation in May and return to the new growths of the hops. Every hop garden in the county should be carefully surveyed each May and directly fresh populations of Red Spider are beginning to build up, precautions should be taken to destroy them. This can be achieved by applying a 1 per cent. lime-sulphur spray to the hops when the new growths reach the tie wire, and before the mites produce their canopy of webbing on the leaves and lay their summer eggs.

19. Hatching of Insects after the Severe Winter.

The unprecedented cold weather of February and March, 1947, followed by the late spring, had a marked effect upon plant growth and indeed many of the less hardy plants and shrubs were killed or badly damaged.

In these circumstances the effect of the severe weather upon certain fruit insects is not without interest. In an average season the Apple Capsid Bug starts hatching sometime about the first week of April and hatching is completed in three weeks. This is precisely what happened in 1947 ; thus the weather conditions did not influence the hatching of the eggs. Also the Apple Blossom Weevil comes out of hibernation in March and starts ovipositing at the end of the month. In 1947 egg laying was first noted on 1st April about the same date as last year.

The Fruit Tree Red Spider started emerging from its winter eggs on 24th April in both Kent and Essex. Precisely the same date as last year.

Three species of apple and plum aphides were noted hatching out during the third week of March ; rather later than usual, but the hatching period of these insects varies considerably in any season.

It seems probable that the species which overwinter in the egg state are unaffected by weather conditions. Those species hibernating as adult or immature forms, however, may be affected considerably, as for example, the Strawberry Aphid. It must be noted that the Apple Blossom Weevil, which hibernates in the adult state, behaved normally in the spring, but it is probable that the population was considerably thinned out by the severe weather.

Another interesting point concerns the species which infest the fruit trees during the summer months. They occur about the same time every year and do not appear to be influenced by the weather whatever the conditions may be. Some years ago the late Professor Theobald referred to the scarcity of aphides in Southern England in 1924, and growers will wait with interest to witness the same phenomenon happen again.

20. Green Wood Peckers " Working " Damson Trees.

During March numbers of Green Wood Peckers were observed " working " some old damson trees growing in an orchard at East Malling. The birds were very persistent in their attacks and considerable portions of the trunks and larger branches were damaged.

A closer inspection showed that the Green Wood Peckers were searching for and feeding upon the Fruit Bark Beetle (*Scolytus rugulosus* Ratz.), a wood boring beetle tunnelling in the trunks and main branches. The birds remained in the orchard until infested trees were grubbed by the grower.

Summary.

Notes are given on twenty insect pests and mites noted in 1947. Reference is made to the effect of weather upon various fruit insects and the absence of the Strawberry Aphid in Kent. *Polydrosus sericeus* Sl., a green leaf weevil, is reported on strawberry. The prevalence of the Hop Red Spider is also noted.

Fig. 1.
Laxton apples damaged by the larvae of the Nutmeg Moth (*Mamestra trifolii* Rott).

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OBSERVATIONS ON THE RASPBERRY CANE MIDGE (*THOMASINIANA THEOBALDI* BARNES) AND ITS ASSOCIATION WITH CANE BLIGHT

By R. S. PITCHER

Introduction.

Work on the biology and control of the Raspberry Cane Midge (*Thomasiniana theobaldi* Barnes) has been proceeding for two years, financed by a grant from the A.R.C. While the problem of control has not yet been solved, much has been learned of the biology of the midge and of the connection between midge attack and the subsequent death of canes generally known as Cane Blight. The knowledge so far gained is set out in this progress report in the hope that it will contribute to a better understanding of the problem.

Historical.

Apart from notes by Theobald (1921) and Harris (1930), the attack of midge larvae and death of canes had been considered as quite separate problems until recent years. Cane Blight was recognized as the cause of the death of fruiting canes in the spring, while the midge was regarded as a relatively harmless insect which lived on the canes in their first year of growth.

Theobald first reported the midge as attacking the variety Bath's Perfection from 1921-26 and described it as " a seriously increasing pest ", but between this date and 1941 little was heard of it. In 1943 a serious attack on Newburgh and other varieties at the R.H.S. Gardens, Wisley, followed by cane death, provided an opportunity for further study (Wilson and Green, 1944). These authors found that there was a definite association between the midge and a fungus, although there was still some doubt which was the primary parasite. If, as was believed, the fungus were a wound parasite, it should have been incapable of entering undamaged canes, although previous attack by midge larvae may have enabled it to become established.

Barnes (1944), however showed that the midge was also incapable of starting a larval colony on a cane without some previous injury to the epidermis. Thus it appeared that a wound was a pre-requisite of both midge and fungal attack and offered equal opportunities to each.

Nevertheless, the fact that severe cane death rarely occurred in the absence of midge attack suggested that the midge was in some way initiating the trouble. Preliminary spraying trials carried out at the R.H.S. Gardens and later at East Malling supported this theory, as a degree of midge control reduced cane death, while applications of fungicides had no effect. For this reason the problem was attacked mainly from the entomological angle, maintaining at the same time close contact with the work of Mr. P. C. R. Webb of the Plant Pathology Section on the mycological aspect.

Biology.

Life History.

Observations made in 1946 and 1947 (to be published more fully later) have confirmed the work of Barnes (1944), who stated that the midge overwinters in the soil and passes through three or four generations annually, pupating in the soil between each. Females, which begin to emerge in late April or early May, each lay up to seventy eggs on the young green canes. The larvae feed under the epidermis, becoming a salmon pink colour when fully grown. They then fall to the ground, burrow into the top half inch of the soil and pupate in cocoons. From these the midges of the second generation emerge in July, giving rise to a larval generation approximately five times as numerous as the first. The third generation, occurring in August, is still more numerous, being approximately eight times as large as the first. There is probably a partial fourth generation. As considerable overlapping of generations occurs, eggs and larvae are present on the canes from early May to mid-September.

Attack on the Canes.

An attacked cane may be recognized by the presence of superficial dark brown blotches, under the most recent of which the colonies of pink larvae may be found. Close observation shows that the female midges always seek some form of a break in the epidermis of the cane before they begin egg-laying. In May the epidermis of some varieties is liable to split locally and these splits are frequently

used by ovipositing females of the first generation. Slug damage and mechanical wounds provide alternative sites. The lesions caused by the first generation are scattered and relatively few.

In July and August the cane matures and grows its winter bark. The cortical tissues outside the cork split and peel back and, while they are still green, the second and third generations of midges lay eggs under them. These splits are extensive and the midge lesions they support are often very numerous producing a mass of irregular feeding areas which are most concentrated at the base of the cane. When severely attacked, all the lower 12in. to 18 in. of the cane may become discoloured. These are the attacks which cause serious cane death. As a result of larval feeding, cork production is inhibited locally while in the surrounding healthy areas corky tissue continues to be laid down. This has the effect of producing shallow depressions which mark the site of the feeding areas. The midge feeds superficially on the developing cork cells and makes no direct attack on the vascular and cambial tissues of the cane. It does, however, deprive the cane of the protection which the cork would otherwise afford.

Fungal Attack.

A few weeks after the larvae have left, fructifications of various fungi can commonly be found on the feeding areas, while the surrounding cork tissue remains free from fungal attack. Thus the split appears as a selective type of wound, resistant to fungal attack but acceptable to the midge. It is only after the midge larvae have fed on the cork tissue exposed by the split that this becomes susceptible to fungal attack.

Two to three months later it is usual to find that not only the cork but also the underlying vascular tissues are dead and discoloured. Thus the affected areas are incapable of carrying food and water and further growth is precluded by the death of the cambium. This damage is local, being confined to the tissues immediately below the midge lesion, but on heavily attacked canes midge lesions are so numerous that enough of the cane is put out of action to kill it during the winter. Such canes fail to break any buds in the spring. Susceptible varieties may lose 75 per cent. of their cane in this way.

Less severely damaged canes may produce fruiting laterals in reduced numbers, only to collapse and die before they can bear fruit.

Varietal Susceptibility.

Except where many varieties are grown side by side, serious midge attack is usually confined to a few susceptible varieties such as Bath's Perfection, Newburgh and Malling Enterprise. Others, such as Norfolk Giant and Malling Landmark, are but lightly attacked and rarely suffer much loss of cane. As mentioned above, the main oviposition sites, used by the important later generations of midge, are the natural splits and if these were not present, no serious midge attack would develop. Although the rind of all raspberries splits to some extent, the susceptible varieties split much more readily than the resistant. In 1947 Malling Enterprise offered three and a half times as much split area per cane as Malling Landmark. It suffered three and three-quarter times as many midge lesions per cane. There may be other factors affecting susceptibility, but at all events, it is clear that a variety which does not split readily stands a much better chance of avoiding serious damage than one which does.

Control.

Chemical.

Control of Cane Blight by fungicides has met with little success. Indeed, it is most unlikely that protective fungicides can effect a control, as the feeding areas of the midge through which the fungi gain entry are closely covered by the peeling rind of the cane and so cannot be reached by the application of spray or dust. Various methods of controlling the midge have been suggested and tried, but results have so far been inconsistent. Once established under the rind the larvae are too well protected to be reached by a contact spray, so attack has to be made on other stages of the midge. Control measures directed against the first generation offer the following advantages :

1. Midge numbers are at their lowest.
2. Damage to canes has not begun.

Two methods of approach have so far been tried :

(*a*) Soil applications against overwintering larvae in cocoons.

(*b*) Destruction of adults before eggs are laid.

(*a*) This method offers a fair chance of success as the top half inch of soil contains most of the larvae. Various rates of application and timings of tar oil and naphthalene have been tried, but neither has given a commercial control. Tar oil has some controlling effect, but subsequent generations soon recover from this initial setback.

(*b*) The use of DDT for this purpose has given varying results, being very promising in preliminary work but less satisfactory in a detailed trial. The technique adopted was to apply the insecticide to the young green canes shortly before the first midges emerged from the soil in the spring. An insecticide for this purpose must have a fair degree of persistence as protection must extend throughout the whole of the emergence period of the first generation of midges (which has varied between three and six weeks in the two years so far covered). At the same time, the ideal insecticide must be quick acting, as under suitable conditions individual midges mate and lay the bulk of their eggs within a few hours of emergence from the soil. DDT may fulfil the first of these conditions, but is in general slow acting. Further work is necessary before any positive recommendation on these lines can be made.

Cultural.

The midge's habit of pupating in the superficial layers of the soil renders it vulnerable to cultural attack, but as many of the cocoons lie close to the bases of the canes they are difficult to reach. Any working of this soil layer will tend to disturb the cocoons and to dry them out if performed under suitable weather conditions. Such work, done at the end of June, will help to reduce the damaging second generation. In winter the turning of furrows close against the bases of the stools will help to bury some of the cocoons.

Summary.

A preliminary account is given of the way in which young canes damaged by the feeding of Raspberry Cane Midge larvae become susceptible to invasion by fungi, being killed before they can bear fruit. Possible methods of control are discussed.

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A PRELIMINARY REPORT ON THE STRAWBERRY EELWORM (*APHELENCHOIDES FRAGARIAE* RITZEMA BOS)

By G. H. L. DICKER

In this country two distinct types of symptoms have long been associated with eelworm infestation of strawberry plants. Towards the end of the last century Ormerod (1898) described a Cauliflower Disease in which severe fasciation occurred to some or all the aerial parts, more especially to the inflorescence. Eelworms obtained from such plants were described by Ritzema Bos as *Aphelenchus fragariae*, a new species. Some years later Wellington (1920) mentioned another descriptive name, that of Red Plant. This term was, unfortunately, used by early workers to include symptoms produced by more than one cause, though at the time the actual agents had not been discovered. For instance, the description by Lees (1922) most probably applied to the disease now known as Red Core and caused by *Phytophthora fragariae* Hickman. Red Plant, as described by subsequent workers is characterized by complete or partial blindness and the presence of small malformed leaves borne on almost hairless petioles. During the spring months certain varieties, such as Royal Sovereign, have the petioles coloured a dark red and the leaves tinged with purple, but this pigmentation vanishes in summer.

Microscopic examination of both types of plants invariably showed the presence of the eelworm, *Aphelenchoides fragariae*, and, from an accumulation of circumstantial evidence of this nature, the eelworm has been considered the causal agent of both Cauliflower Disease and Red Plant. Doubt has sometimes been cast on these conclusions for previous workers failed to reproduce the symptoms by direct inoculation. Moreover, the same species of eelworm was often found in apparently healthy plants and Lacey (1936) obtained evidence that Cauliflower Disease was caused by *Corynebacterium fascians* Tilford.

A. fragariae also occurs in the U.S.A. where it causes a disease of strawberries described as Dwarf (Stevens and Mook, 1930), Crimp (Brooks, 1931) and Spring and Summer Dwarf (Christie, 1938). The last named author showed there were two strains of the nematode, one causing Spring Dwarf in the north-eastern States and another in the southern States producing similar symptoms later in the year, which he called Summer Dwarf. Christie also proved by inoculation that the eelworm was the cause of these troubles.

Recently a great effort has been made to improve the health of strawberry stocks in this country by raising special stocks of runners in areas isolated from fruiting plantations and rogueing at intervals throughout the growing season to remove virus-infected plants. Many plants, resembling Red Plant, have been noted in such stocks of the variety Royal Sovereign and this has led to an investigation of the Strawberry Eelworm. Studies are not yet complete, but inoculation experiments have already given positive results and it has been considered opportune to present the information so far obtained.

Symptoms Observed in the Field.

In addition to typical Red Plant, many plants of the variety Royal Sovereign have been observed in which only occasional leaves showed abnormality. In its mildest form this consists of a yellowing or browning of the tissue on the dorsal surface at the base of the midrib, it sometimes also extends a short distance along the lateral veins arising from this area. The surface of the discoloured area is hard and rough. These symptoms are often accompanied by a shortening of the stalks of the leaflets, causing the laminae to overlap considerably. Similar discoloured areas occur at the base of the petiole and on the stipules. In extreme cases these areas may extend along more than half the total length of the midrib producing a leaflet which is deeply channelled down the centre where the two halves have failed to separate completely and the laminae are coarsely puckered and twisted (Fig. 1). The twisting can be observed before the leaflets unfold ; at this stage the discoloured tissue is pale yellow and covered with eelworms which, when viewed with the naked eye or through a hand lens, appear as a white woolly mass. Similar symptoms have been described by Ogilvie and Thompson (1936) from the west of England and Klinkenberg (1947) from Holland.

Runners from infested plants may show leaf symptoms from August onwards and, in the following spring, develop into Red Plants. On the other hand, many infested runners do not develop symptoms until the summer following planting ; leaf puckering becoming most common in early autumn and

continuing until growth ceases. Generally, however, it is during the second spring when leaf growth commences that these distorted leaves are most prevalent and a month or two later, about May, a typical Red Plant appearance is assumed due to destruction of the crowns.

Inoculation Experiments.

The plants used were of the variety Royal Soverign, all rooted directly in pots from a single virus-free parent and kept in an insectary. At the beginning of the experiment each runner possessed from three to five leaves. Eelworms were obtained from young leaves of Royal Sovereign plants growing in a field at Wye.

Experiment 1 (13th September, 1947). One plant inoculated by pouring an aqueous suspension of eelworms over the crown ; five plants inoculated by transferring a mass of eelworms on a fine needle and placing it between the stipules of the youngest leaf and the crown. By 17th October the plant inoculated with the aqueous suspension had an unfolding leaf showing yellowing at the base of the midrib and a twisting of the leaflets. One more leaf produced in early November before growth ceased showed no symptoms. Of the other five plants, one showed definite leaf symptoms by 2nd October and two more by 7th October ; on all these plants masses of eelworms could be found between the dorsal surfaces of folded leaflets. Each plant produced one more leaf before growth ceased but it showed no symptoms, indicating reduced eelworm activity. The remaining two plants developed no symptoms and were re-inoculated on 1st November by placing an infested young leaf on the crown of each. Six control plants all remained healthy.

Experiment 2 (9th October, 1947). Two plants inoculated by pouring an aqueous suspension of eelworms over the crowns ; six plants inoculated by transferring eelworm masses on a fine needle as before. Slight symptoms developed on one plant inoculated by the needle method by 1st November, the remainder produced normal leaves until growth ceased.

Experiment 3 (21st October, 1947). Two plants inoculated by placing an infested young leaf on the crown of each. No symptoms developed in 1947.

When autumn growth ceased in November it was already perfectly clear that leaf symptoms similar to those observed in the field could be obtained by artificial inoculation. Observations were continued when growth began in February but, as subsequent records showed no marked differences between plants composing the various experiments or methods of inoculation, all sixteen plants are summarized together below.

By 18th February, 1948 the first young leaf was emerging from the crown of each plant. Even while still tightly folded the leaves from eleven plants exhibited various degrees of browning, ranging from slight discoloration of the external lobes of the lateral leaflets to complete browning of the entire leaf, with leaves brown at the base and green at the tip predominating. The majority of these leaves died while the petiole was still less than half-an-inch long, the others developed into small malformed leaves showing large discoloured areas in the basal halves of the leaflets. Two of the five remaining plants developed symptoms when further leaves appeared, the other three remained normal.

By mid-March the primary crowns of the most heavily attacked plants had ceased to produce any leaves and daughter crowns were appearing. In early April those plants in which the primary crown had been killed assumed an appearance which approximated very closely to the earlier descriptions of Red Plant (Fig. 2). The centre of the plant became bare and the leaves from the daughter crowns were small and borne on slender petioles. Later no complete blossom trusses appeared though two plants produced single malformed flowers, composed of small twisted sepals with rudimentary petals and sexual organs, on stalks about an inch long. The six control plants and the three inoculated ones which developed no symptoms each continued to produce normal healthy foliage and one strong blossom truss.

Thus, from sixteen plants inoculated with *A. fragariae*, thirteen developed symptoms similar to those observed in the field whilst six untreated plants from the same clone remained healthy. This provides ample evidence to prove that the eelworm is the primary cause of the symptoms already described, including Red Plant. No symptoms of Cauliflower Disease have been obtained.

Habits of the Eelworm.

Observations indicate that the eelworms are normally found in the crown of the plant where they live ectoparasitically on all tissues. Many congregate between the folds of developing leaves especially along the midribs and under the folded external lobes of the lateral leaflets. As the petiole lengthens they are carried upwards from the crown and remain within the leaflets until unfolding takes place. Then, due to a negative phototropic response, a drop in humidity, or both, they descend the petiole to the crown when a film of moisture is present ; this may be in the form of dew or during rainy periods. The discoloured areas are caused by the eelworms feeding on the epidermal tissue ; the degree of

malformation depends on the population and rate of development of the leaf. Evidence so far accumulated shows that leaf symptoms are greatest in the early spring and in the autumn when plant growth is slowest, they may also be intensified during the summer months when drought retards growth. Only at the commencement of growth in the spring have leaves on observation plants been actually killed and these, of course, were differentiating in the crown throughout the winter and thus subjected to eelworm attack for an unusually long period. This also indicates that eelworm activity continues throughout the winter. As the spring advances and growth rate increases the severity of the leaf symptoms decreases.

A considerable proportion of the total eelworm population is always present in the crown and the injury caused by feeding may kill the growing point. This has been noted as early as mid-March and results in secondary crowns appearing prematurely, producing a plant with small leaves borne on slender stalks. In turn the secondary crowns become invaded with eelworms, resulting in further weakening of the plant, and it is at this stage that the typical Red Plant appears.

Both blossom trusses and stolons arise from buds in the axils of the leaves and in heavily infested plants these are so damaged by eelworms as to produce little or no blossom and very few runners. Eelworms are often found in the tips of stolons arising from infested plants and this is considered the chief means whereby the pest is spread. It is also probable that healthy plants may become infested from contaminated soil, but at the moment there is no information on the distance eelworms will travel in soil moisture. As far as is known the eelworm has no host plant other than the cultivated strawberry.

Varietal Susceptibility.

The present investigation has been concentrated on the variety Royal Sovereign. Similar leaf symptoms have also been observed in Oberschlesien. An experiment to test varietal reaction to eelworm is now in progress. During June, 1947, the author visited beds of Royal Sovereign in Cornwall where the leaves exhibited a uniform crinkling but no discoloured areas were noted. At the same time plants of Madame Lefebvre were observed in the Tamar Valley exhibiting symptoms of the Cauliflower Disease type. No eelworms were isolated from these plants but previous cropping history of the fields suggested that the Stem and Bulb Eelworm *Anguillulina dipsaci* Kühn may have been responsible and it is hoped to test this species shortly.

Control Measures.

No satisfactory control measures have yet been evolved. Preliminary experiments indicate that the warm water treatment used to control the Strawberry Tarsonemid Mite is unlikely to give a complete kill of eelworms and Christie and Cobb (1940) doubt whether fumigation with methyl bromide will prove effective.

Until this problem has been solved the only means of reducing damage by this pest will entail careful rogueing of runner beds and the removal of all plants exhibiting symptoms of eelworm attack. The first inspection should be made in March when leaf symptoms and possibly dead crowns are visible. Another opportunity will occur at the time of deblossoming and a further inspection should take place in August or September. All runners arising from the infested plants must be removed and in special stocks the entire block should be grubbed.

Acknowledgement.

The author is greatly indebted to Miss M. T. Franklin for confirming the identity of the eelworm.

Summary.

Royal Sovereign strawberry plants have been observed in the field with deformed leaves. The symptoms consist of a browning or yellowing on the dorsal surface at the base of the midrib ; sometimes discoloration also extends along the lateral veins arising from this area ; in addition the leaflets exhibit various degrees of puckering and twisting. Eelworms obtained from such plants have been identified as *Aphelenchoides fragariae* Ritzema Bos and when transferred to healthy Royal Sovereign plants have produced similar symptoms.

Biological observations have shown that the main eelworm population lives in the crown of the plant, the growing tip of which may be killed, causing the premature production of secondary crowns. These in turn become invaded with eelworms and produce the condition known as Red Plant.

Preliminary experiments indicate that immersion of infested plants in water at 110° F. for twenty minutes is unlikely to give a complete kill of eelworms. At the moment the most satisfactory control would appear to consist of rogueing infested plants from runner beds in March, May and late summer.

Fig. 1.

Royal Sovereign Strawberry plants showing leaf symptoms due to eelworm attack.

[*face p. 146*

FIG. 2.

Royal Sovereign Strawberries ; the three bottom plants have been inoculated with eelworms which have killed the primary crown : the top plant is a control.

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HOPS

VERTICILLIUM WILT OF THE HOP *(HUMULUS LUPULUS)*

A NOTE ON THE INCIDENCE OF SYMPTOMS OF FLUCTUATING WILT IN EARLY, MID-SEASON AND LATE BINE

By W. G. KEYWORTH and MARGARET M. HITCHCOCK

Fluctuating wilt of the hop, which is present in many hop gardens in the South-East and West Midland hop growing areas, is caused by a mildly pathogenic strain (or strains) of the soil fungus *Verticillium albo-atrum*. The most common symptom is the swelling of one or more of the bines (stems) on affected plants, the wood in such bines being light brown in colour, but sometimes the leaves may become yellow or wilt, and occasionally the whole bine may wilt and die. The disease rarely kills the plants, however, and plants affected in one season may appear normal next year and vice versa. There is evidence that the fungus is often widespread throughout affected hop gardens (Keyworth, 1948), and that the occurrence of symptoms on individual plants depends on local soil factors (e.g. impeded drainage) (Harris, 1936). The severity of the symptoms and the number of affected plants vary from year to year in a manner apparently correlated with annual rainfall.

Some growers have reported that, in addition to the factors described, the number of affected plants and the severity of symptoms may also be influenced by the " forwardness " of the bine. To test this hypothesis, experiments were carried out in 1945, in which, by using different times of " dressing " and " training ", plots of plants in one field on each of two farms were treated to produce early, normal and late bine,* as follows :

Farm No. 1.

Treatment.	*Dressed.*	*Trained.*
A	21st February	16th April.
B	8th March	23rd April.
C	30th March	16th May.

Farm No. 2.

Treatment.	*Dressed.*	*Trained.*
A	16th February	5th April.
B	1st March	25th April.
C	31st March	15th May.

The three treatments were randomized, and replicated five times, the individual plots being rows of from 55 to 70 plants across the field.

Records of the plants showing swollen bines or more severe symptoms (i.e. leaf yellowing or wilting) were made throughout the season. A fair proportion of plants showed symptoms on Farm No. 1, but on Farm No. 2 very few plants in any of the treated plots showed symptoms.

The results are indicated in Tables I and II.

On Farm No. 1 treatment C resulted in a significantly smaller number of plants showing symptoms than treatment A. Treatment B gave an intermediate number of such plants but was not significantly different from either A or C. The proportions of affected plants severe showing symptoms were not influenced by the treatments, however. It thus appears that the effect of treatment C was to reduce the number of plants showing symptoms but not to affect the severity of those symptoms.

The results obtained on Farm No. 2, although inconclusive because of the small number of affected plants, also suggest that treatment C gave a reduced number of such plants.

* Hop plants are generally dressed in February or March, an operation involving the removal of the basal portions of the previous season's bines. A succession of shoots then grows from the rootstock and it is the usual practice in April or May to pull out those arising early and late, training six or eight of the remainder up the strings to grow and produce the crop. Within limits the time of cropping can be adjusted by varying the time of dressing and by selecting early or late bine for training.

TABLE I.

WILT RECORDS. FARM NO. 1.

Treatment.	No. of Plants.	No. of affected plants.	No. of these with severe symptoms.	No. bines on affected plants.	No. of these swollen.
A.	327	51	29	426	242
B.	313	33	19	274	119
C.	307	22	14	160	63

It was not possible to take crop records but there appeared to be no considerable reduction in crop on the late bine treatment. It thus appears that this treatment may be used, if necessary, to reduce the number of plants showing symptoms of fluctuating wilt. The reasons why such a treatment has this effect are obscure but it is possible that one factor may be the shorter time that the late bines are growing, and thus presumably under the influence of fungal invasion.

TABLE II.

WILT RECORDS. FARM NO. 2.

Treatment.	No. of plants.	No. with swollen stems.
A.	313	12
B.	303	12
C.	313	3

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NETTLEHEAD DISEASE OF THE HOP

A NOTE ON THE REACTION OF CERTAIN WYE SEEDLING VARIETIES TO GRAFT INFECTION

By W. G. KEYWORTH

Prior to 1939, Nettlehead disease had not been seen in commercial plantings of the Wye seedling varieties of hop although it was widespread in commercial Fuggle gardens. It was, therefore, suggested by Salmon and Ware (1936, 1937) and later by Ware (1939) that the replanting of severely affected Fuggle plantations with these varieties might provide a control of the disease.

Commercial test plantings were considered during the course of the research on this disease undertaken at East Malling after 1939, but before making field trials it was decided to determine the reaction of a number of the commercially acceptable seedling varieties to graft infection. In 1942 a severe outbreak of Nettlehead was seen on one farm in the variety Brewer's Gold and several infected plants of the variety Fillpocket were noted elsewhere. As it was thus clear that these two varieties could show symptoms they were not included in the tests.

1943 and 1944 Tests.

Eighteen varieties were tested in all, of which nine were in commercial use and the others were varieties showing some resistance to Verticillium Wilt. Grafts were made in 1943 and 1944, some of the varieties being tested in both years. The methods employed were similar to those previously described by Keyworth and Davies (1946), each plant to be tested being inarched in the glasshouse to a single Fuggle plant infected with Nettlehead. The infector plants were non-clonal and grown from cuttings taken from infected plants in commercial gardens. Nominally, five plants of each variety were grafted (ten in the case of the Fuggle controls) but losses, due to unsuccessful grafts and the death of some of the plants, considerably reduced the numbers which could eventually be recorded. As noted by Keyworth and Davies (*loc. cit.*), symptoms of Nettlehead rarely appear on indicator plants in the year in which they are grafted, particularly under glasshouse conditions. All the test plants were, therefore, grown out-of-doors to observe symptoms during the year subsequent to grafting. Records were taken on several occasions throughout the growing season.

Details of the varieties used and summaries of the series of symptom records made in each season are given in Table I.

TABLE I.

RECORD OF SYMPTOMS ON VARIETIES TESTED IN 1943 AND 1944.

Variety.	1943 grafts (recorded 1944).			1944 grafts (recorded 1945).		
	No.	Definite symptoms.	Slight symptoms.	No.	Definite symptoms.	Slight symptoms.
OB53 (Nonsuch)	4	4		4	2	2
N15 bis (College Cluster)	2	1		4	3	1
X35 (Early Promise) ..	3	2	1	5	2	1
OP21 (Brewer's Favourite)	4	3	1	5	5	
HH44 (Brewer's Standby)	5	2	1	5	2	1
OO63 (Quality)	4	1	1	5	2	
BB28 (Malling Midseason)	3	1	1	4	2	
Q43 (Bullion)	4	2	1	3	0	
OH44 (Concord)	5	0		4	0	
OZ79	3	2		–		
OQ4	3	1		–		
OR55	–			4	2	1
OJ47	–			3	3	
OT91	–			5	5	
AEE55	–			4	2	2
EE77	–			2	1	
V32	–			4	1	
A0010	–			4	2	1
Fuggle	7	5		10	4	

As will be seen, many of the grafted plants, including a number of Fuggles, failed to show symptoms. This was thought to be due partly to unsuspected graft failures and partly to the high degree of symptom masking occurring in both seasons, particularly in 1945. This lack of symptoms in many of the Fuggle control plants and the small numbers of each variety which were used, invalidate any comparison of the varieties in respect of their reaction to graft infection. It will be noted, however, that, with the exception of the variety Concord, at least one plant of every tested variety showed symptoms and it may thus be concluded that they are all sensitive to some degree. The variety Brewer's Favourite showed the leaf-roll symptom readily and most of the infected plants were considerably stunted by the disease.

Further Test of the Variety Concord.

The fact that none of the grafted plants of the variety Concord showed symptoms in 1944 suggested that this variety might show complete or partial tolerance to Nettlehead infection. A more detailed test of this variety was therefore made in 1945 as follows.

Thirty non-clonal Fuggle plants infected with Nettlehead (as used in the previous experiments) were each inarched to a healthy plant of the variety Concord and also to a healthy Fuggle plant. Failure of some of the grafts reduced the eventual number of graft units (i.e. Concord—Nettlehead Fuggle—Fuggle) to twenty-two, the sixty-six plants of which were grown in the glasshouse during 1945 and then planted out of doors for observation in 1946. Records were made on six occasions in this year, from 10th May to 24th August, any symptoms noted being classified as definite or slight. The numbers of plants recorded on each occasion are shown in Table II.

TABLE II.

SUMMARIES OF THE SYMPTOM RECORDS MADE ON THE INTERGRAFTED CONCORD TEST PLANTS, FUGGLE INFECTOR PLANTS AND FUGGLE INDICATOR PLANTS ON SIX OCCASIONS DURING 1946.

Date of Record.	Concord.		Infector Fuggles.		Fuggle.	
	Definite Symptoms.	Slight Symptoms.	Definite Symptoms.	Slight Symptoms.	Definite Symptoms.	Slight Symptoms.
10th May ..	1	6	9	11	6	8
20th May ..	0	11	12	5	7	8
11th June ..	3	6	12	4	3	8
24th June ..	7	5	11	6	12	3
8th July ..	10	3	16	3	12	5
24th August ..	12	4	11	9	15	4

It is clear that plants of the variety Concord can show symptoms and the variety is thus not completely tolerant to Nettlehead. The results indicate, however, that the symptoms appeared later on the Concord plants than on the comparable Fuggle plants. This was reflected in the general growth of the infected plants of both varieties, those of the variety Concord being of a good size with symptoms eventually appearing on laterals or near the tips of the bines, whereas the Fuggles were generally stunted by the disease. It should be noted that the cool conditions prevailing in 1946 encouraged the ready display of Nettlehead symptoms.

Discussion

The experiments and field observations described, show that none of the twenty varieties studied is immune or completely tolerant to Nettlehead. There is some evidence, however, that at least one variety, Concord, may show symptoms less readily than the Fuggle variety.

Although, as pointed out by Salmon and Ware (*loc. cit.*), some control of Nettlehead might be obtained by the use of a variety which does not readily show symptoms, the method has one disadvantage. If infected plants cannot readily be detected and removed, they may constitute a danger to other varieties nearby, a factor of particular importance in the case of Nettlehead since all the hop varieties commonly grown at present can be severely affected by the disease. It is thus of importance from both points of view to follow up the preliminary results already obtained by means of more extended field trials.

Summary.

An account is given of small scale experiments to test the reaction of eighteen Wye seedling hop varieties (including nine named varieties) to graft infection with Nettlehead. At least one plant of every variety showed symptoms and thus none is completely tolerant. Insufficient tests were made to permit of comparisons between the varieties in respect of degrees of symptom expression but in a subsequent trial of the variety Concord, symptoms appeared later and were less severe on plants of this variety than on comparable Fuggle plants.

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AERIAL SURVEYS OF THE INCIDENCE OF NETTLEHEAD DISEASE OF THE HOP ON FORMER HEDGEROW AND PASTURE SITES

By W. G. KEYWORTH and MARGARET M. HITCHCOCK

Nettlehead disease of the Hop was shown to be graft-transmissible by Keyworth and Davies (1946). It is thus presumably of virus origin, but it has not been transmitted by sap inoculation nor has any insect vector yet been found.

Duffield (1925) reported that the disease appeared particularly prevalent in hops planted some years previously on ploughed pasture land and also frequently occurred near hedgerows. These observations were supported by those of Keyworth and Davies and by reports from growers over many years. Some growers also reported that outbreaks of Nettlehead often started or remained more severe where old hedgerows or trees had been grubbed prior to planting. Verification of these somewhat indefinite reports by critical field observations was very difficult, however, and, in the first place, some rapid method of disease surveying was clearly required for selecting suitable outbreaks for detailed study. This need was met in 1946 by aerial surveys, which were made by the owners of a large hop farm on which outbreaks of Nettlehead occurred. Two surveys were made, one on 2nd July and the other on 31st August, from aircraft flying at 1,100 feet and at 2,550 feet.

In vertical aerial photographs the hop plants appear dark against a light soil background. A progressively larger area of soil is obscured by each plant throughout the season until, in late August, practically no soil is visible in a normal hop field. Groups of stunted plants or gaps can thus be detected at any time during the year as light-coloured areas, but particularly so towards the end of the season. In the surveys described, the distribution of these light-coloured areas was clearly visible and they could readily be located on the ground owing to the regular spacing of the plants. A preliminary ground survey showed many of them to be associated with plants stunted by Nettlehead disease and those displaying features of interest were therefore selected for special study.

1. Site of Former Hedgerow.

A hedgerow effect was particularly clear in two adjacent fields. The aerial photograph (Fig. 3,) showed small clear areas evenly scattered throughout the greater part of both fields. Across the centre of both fields, however, an irregular clear area, some six plant intervals in width, was apparent. Reference to the 1911 edition Ordnance Survey map (Fig. 1) showed that this band followed exactly the line of demarcation between two other fields which formerly occupied this site. A study of the farm records revealed that there had been a hedge and ditch between the two fields. The hedge was removed and the ditch piped and filled in in 1933 prior to the planting of both fields with hops, a roadway running north-south being left dividing the two new hop fields.

A ground survey was made of an area including the hedgerow site in July, 1946, the results of which are indicated in the map shown in Fig. 4. As will be seen, the survey demonstrated that Nettlehead plants and gaps were evenly scattered except along the line of the former hedgerow where they were greatly concentrated. Most of the gaps were reported by the grower to be caused by the removal of plants affected with Nettlehead. There thus appeared to be some association between the hedgerow or ditch present thirteen years previously and the distribution of plants which were showing symptoms in 1946, or had done so prior to this date.

2. Comparison of Former Pasture and Arable Fields.

Another field was selected for the study of this effect. Reference to the old Ordnance Survey map (Fig. 2) showed that it originally comprised three fields (marked A, B and C). The farm records indicated that, prior to 1935, field A had been permanent pasture and the other two fields had been arable ground. Hedges separated the fields. In 1935 the hedges were removed and the whole area was ploughed and planted with hops from a uniform source. An aerial photograph taken in July, 1946 (Fig. 5) showed a fairly even stand of hops in areas B and C, but a large number of gaps and weak plants in area A. This is more clearly indicated in the later photograph of parts of the two areas A and B (Fig. 6).

FIG. 1.

Ordnance Survey map of the site illustrated in Fig. 3 showing the position of the old hedgerow.

(Reproduced from the Ordnance Survey map with the sanction of the Controller of H.M. Stationery Office by Headley Brothers, Ashford and London.)

Owing to its size, it was not possible to map the whole of the field, but the presence or absence of symptoms was noted on every fifteenth plant in the whole of area A (about five acres) and in an adjacent part of area B about six acres in extent. From this it was found that 9·7 per cent. of the plants in area A showed Nettlehead symptoms, compared with 0·4 per cent. in area B. Thus, eleven years after they were planted, a considerable difference in Nettlehead incidence was apparent between the original fields, presumably connected in some way with their prior cropping. No information was obtainable however on other related points of difference, e.g. drainage or previous manurial treatment.

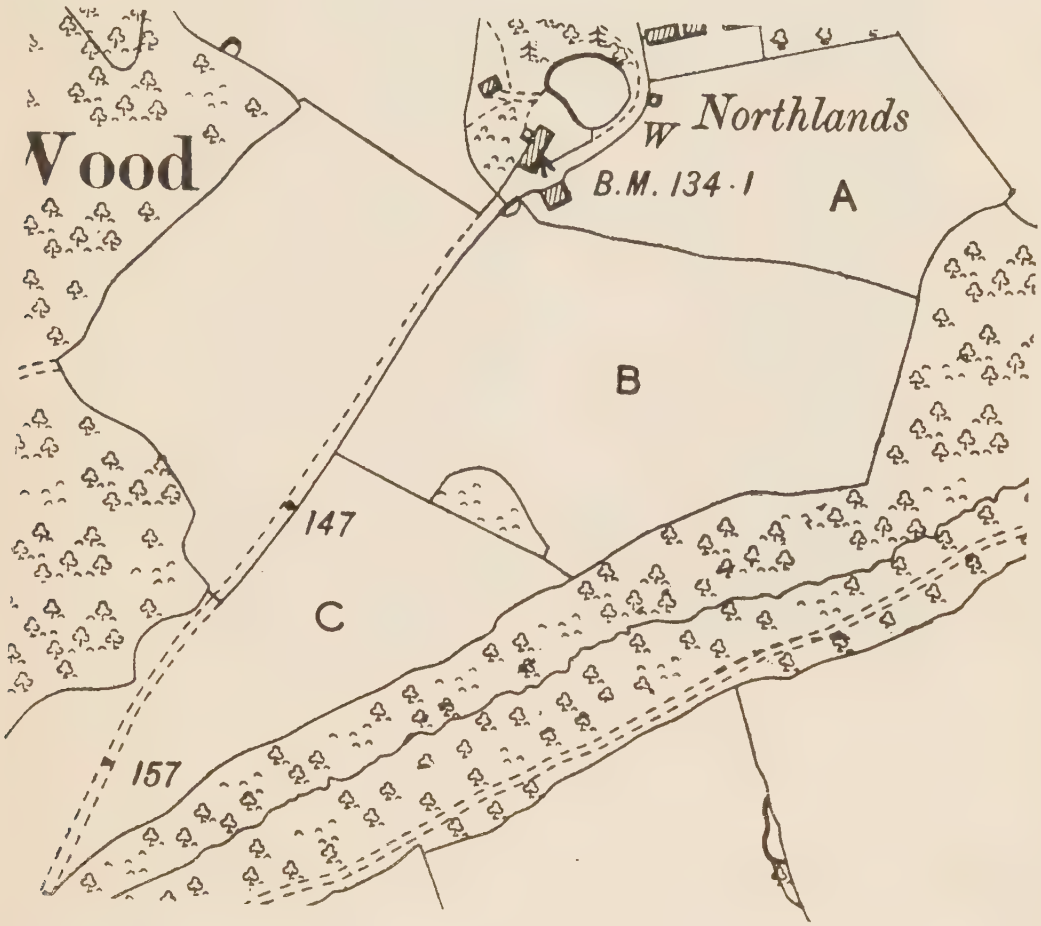

Fig. 2.

Ordnance Survey map of the field illustrated in Fig. 5. Showing the original fields (A-pasture, B and C-arable).

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Conclusion.

The aerial surveys and subsequent field observations described provide conclusive evidence that plants showing Nettlehead symptoms are sometimes especially concentrated on the sites of former hedgerows and pasture fields. It must be emphasized, however, that many Nettlehead outbreaks not associated with such sites have been seen, and that in other cases, hops planted where old hedgerows have been grubbed have remained free from the disease. No information is available on the soil and plant conditions prevailing on the sites described and the causes of the effects observed therefore remain obscure.

Acknowledgement.

The authors are greatly indebted to Messrs. A. Guinness, Son & Co. Ltd., for permission to reproduce the aerial photographs and also for their very helpful co-operation throughout the whole of the investigation.

Summary.

The results of aerial surveys and subsequent ground mapping of outbreaks of Nettlehead disease of the hop are described.

A preponderance of plants showing symptoms was found on the sites of old hedgerows in certain fields. In another field there were many more affected plants on a part that had formerly been old pasture than on the formerly arable section. No evidence was obtained on the basic causes of the effects observed.

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Keyworth, W. G. and Davies, D. L. G. (1946). Nettlehead disease of the hop. *J. Pomol.*, **22**, 134.

[*Photo Hunting Aerosurveys Ltd*

Fig. 3.

Aerial photograph of two hop fields illustrating the hedgerow effect (see Fig. 1). Note. The rectangular clear area on the right-hand side is caused by plants severely affected with Downy Mildew.

Fig. 4.

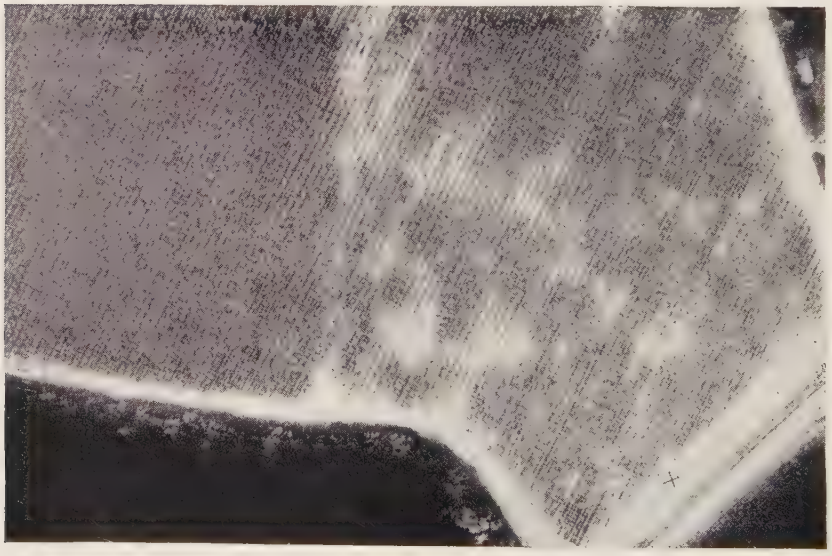
Ground survey of portion of the two hop fields shown in Fig. 3, illustrating the preponderance of plants showing symptoms of Nettlehead along the site of the former hedgerow.

[*face p. 156*

[*Photo Hunting Aerosurveys Ltd*

FIG. 5.

Aerial photograph of a hop field comprising three former fields (see Fig. 2). Note patchy appearance of upper part of field—formerly pasture.



[*Photo Hunting Aerosurveys Ltd*

FIG. 6.

Aerial photograph of a portion of the hop field shown in Fig. 5 taken later in the season and illustrating more clearly the contrast between the arable and pasture sections.

Section IV

BULLETINS FOR FRUITGROWERS

INTENSIVE METHODS OF APPLE AND PEAR GROWING*

By A. BERYL BEAKBANE

The trend towards simplification in form and line in the design of many everyday things can be seen in the development of new forms of tree for garden use. The elaborate fans, espaliers and winged pyramids of former times are giving way to cordons, dwarf bushes and dwarf pyramids. We may still admire the beauty of the older forms and use them occasionally for decorative effect, but lack of time and labour may lead us to choose some form of tree which will bear fruit more quickly and require less detailed care and attention.

The value of a simple tree form, the dwarf bush on a rootstock which will keep the tree very small though growing and fruiting healthily for at least thirty years, has been proved by Dr. R. G. Hatton at East Malling in the course of his work on fruit tree rootstocks (Fig. 1).

We owe the cordon system of cultivation to France where it was largely developed by M. du Breuil. Some of the first cordons to be grown in England were planted in 1861 and 1865 by Sir Henry Scudamore-Stanhope against a brick wall at Holme Lacy in Herefordshire. Cordon trials were planted at East Malling from 1921 onwards (Fig. 2).

The dwarf pyramid form has been used at East Malling in trials of intensive methods of cultivation (Fig. 4). An early record of trees grown in this shape was made by M. Lorette who grew fuseaux at Wagnonville from about 1900 (Fig. 3). The pioneer work in developing the dwarf pyramid system in England was carried out by Mr. A. H. Lees and his system has been further modified by Mr. A. D. Turner in his trials at the Somerset Farm Institute at Cannington. These systems differ considerably from that used by M. Lorette, especially in the treatment of the lateral shoots.

A tree of similar shape to the dwarf pyramid though considerably larger is grown widely in the Rhineland under the name of Spindelbusch. The rootstock most commonly used is M.IX. The trees are planted farther apart and less summer pruning is practised than is usual under the English dwarf pyramid system. The branches are trained horizontally by tying them down to the main stem with string or bending them down with metal clips.

Although strictly speaking the intensive cultivation of apples and pears has as its aim the production of a high yield from a small area of ground, there is, as yet, little experimental evidence as to whether an acre of dwarf trees with 2,000 to 4,000 trees per acre would yield more or less fruit at maturity than an acre of large bushes or standards with about forty trees to the acre. There is, however, plenty of evidence that the small trees would come into bearing first and yield higher crops in the early years provided they were on suitable rootstocks. Trees in our cordon trials at East Malling have yielded a crop equivalent to 700 bushels per acre at ten years old which would be a good yield for any type of tree. The productiveness of a given area of land may also be considered to be increased by the use of intensive methods on account of the higher proportion of first-grade fruit which is normally present in the crops from intensive as compared with extensive trees.

In planning a garden we may decide to devote from one-twentieth to one-tenth of the area to apples and pears. Examples within this range would be 1½ rods in a garden of ½ acre or six rods in half an acre. Even the larger of these spaces could be filled by one large tree if we chose a tree on a vigorous rootstock and allowed it to develop to its full extent, whereas with cordon trees on dwarfing rootstocks we could have up to 100 trees in the same space. This would make it possible to grow a good selection of varieties, and for most people it would provide more interest than could be derived from a single tree. Since the choice of varieties is a personal matter varying with individual preferences for particular flavours and textures, no list of varieties suitable for intensive methods is given here. The Royal Horticultural Society's leaflet entitled " A Selected List of Hardy Fruits for Private Gardens " may be used as a general guide. Trials at East Malling have shown that, contrary to popular opinion, even a tip-bearing variety of the somewhat intractable habit of Worcester Pearmain can be grown successfully by intensive methods provided the right rootstocks and pruning methods are used. Therefore although

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it would be wise to choose as many as possible of the spur-bearing varieties, such as Cox's Orange Pippin, rather than the tip-bearers of more straggly habit, such as St. Everard and Cornish Gillyflower, some of these may be included where the fruit is of high quality. With pears it is best where possible, to choose varieties of compact growth such as Conference rather than very upright and vigorous kinds of which Beurré Superfin is an example.

The question of pollination must be borne in mind when choosing varieties. This subject has been fully studied by Mr. M. B. Crane at the John Innes Horticultural Institution and his results published in their leaflet No. 4, *The Fertility Rules in Fruit Planting*. The information in this leaflet is of the greatest value to those who are planning a fruit garden.

One of the most important of the initial choices is that of rootstock. Fortunately the recommendations can be very simple for intensive apple and pear trees ; although many new rootstocks are being tested for apples and may eventually provide some which are especially suitable for intensive trees.

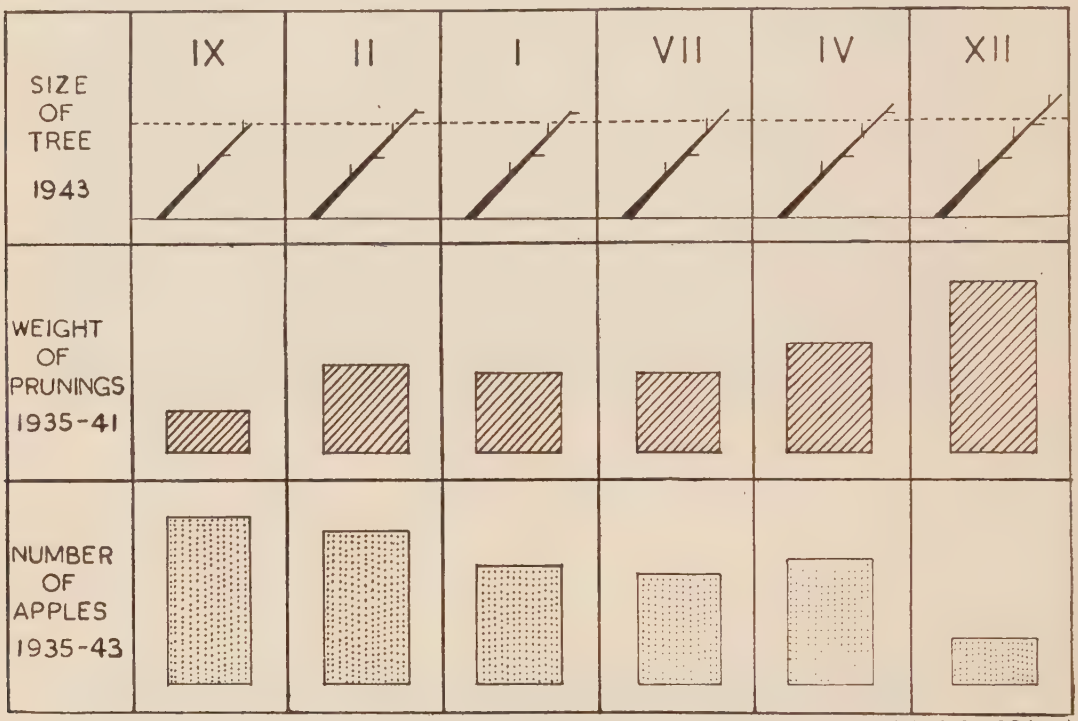

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DIAGRAM 1.

Comparison of rootstock effect on the vigour and cropping of apple cordons.

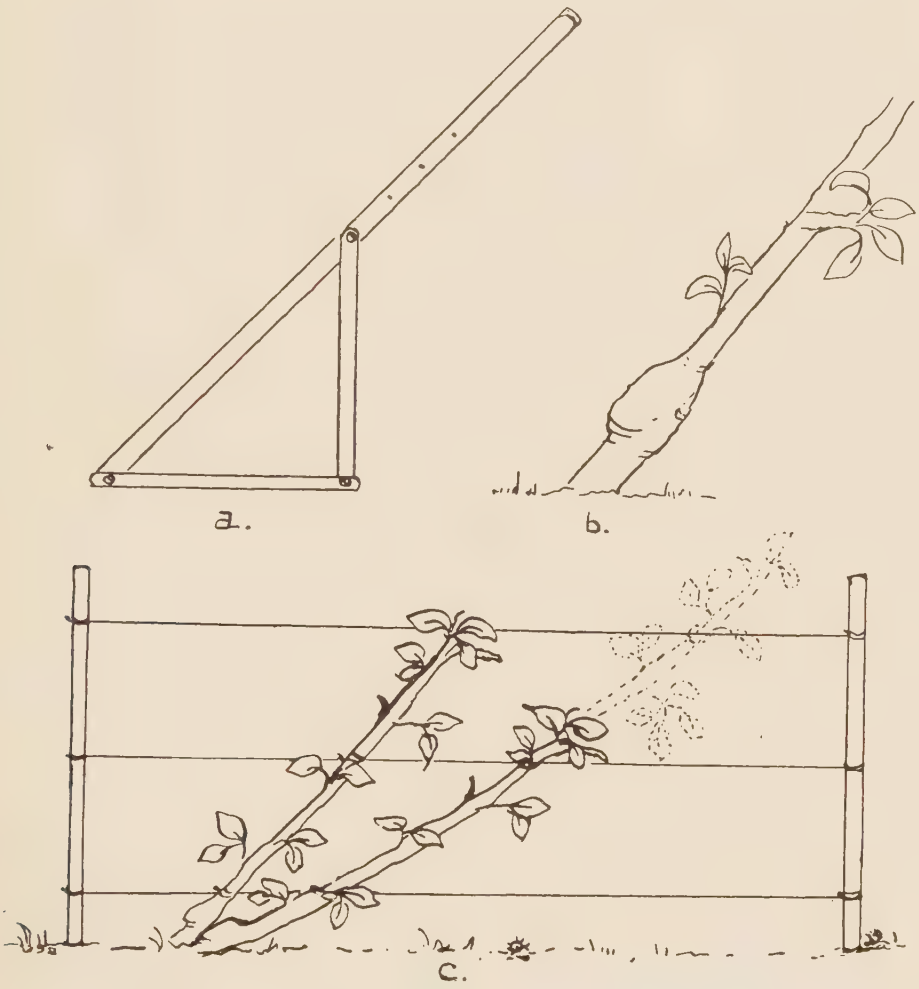
At present, however, for dwarf bushes on most soils one may recommend M.IX for any apple variety except ornamental Crab Apples. M. IX is also the most suitable rootstock for cordons of all spur-bearing varieties. Trials at East Malling have shown that for varieties which tend to produce bare wood when grown in the cordon form it may be wise to choose a more vigorous rootstock such as M.II or M. VII which will tend to encourage the development of more vegetative buds and to furnish the cordon with lateral shoots which can be pruned to form fruiting laterals. M.II and M.VII are also suitable for dwarf pyramids and can be grown without any form of support, although where some simple support such as a single wire can be provided, dwarf pyramids can be grown successfully on M.IX and will bear fruit earlier in their life than trees on more vigorous rootstocks. For large espaliers and other elaborate forms a rootstock at least as vigorous as M.II should be used.

The relative vigour and fruiting of apple cordons on six rootstocks is shown in Diagram I from which it can be seen that trees on M. IX gave the highest crop while requiring the least labour in pruning. Trees on M.II also fruited well, but they did not come into bearing at such an early age as those on M.IX and required considered more labour for pruning.

For pears, Quince A or C would be the most suitable rootstock, remembering that certain pears such as Williams' Bon Chrétien should be double worked as they prove to be incompatible when budded directly on to the quince stock.

In choosing the exact type of tree for a garden the merits of the different forms may be considered. The single oblique cordon normally bears fruit earlier in its life than either the dwarf pyramid or bush. As against this advantage, however, we must set the difficulty of providing the elaborate erection of poles and wires needed to support cordons. Dwarf bushes are relatively easy to stake and dwarf pyramids may often be grown without stakes.

Trees for all three forms described should be planted with the unions about three inches above ground level to prevent scion-rooting. If roots of a vigorous variety are allowed to develop above the



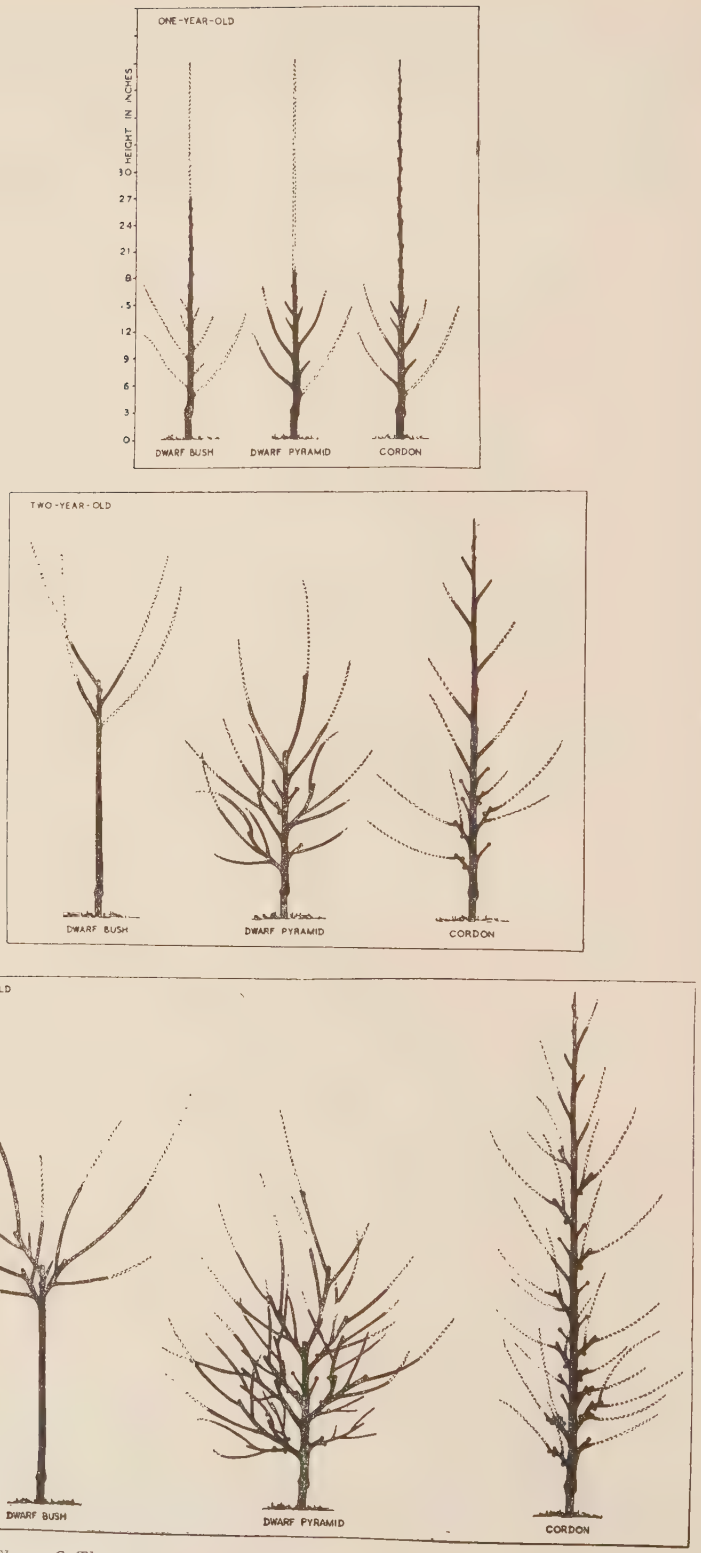
Drawings by Barbara M. Stokes.

DIAGRAM 2.

Illustrating methods of planting and training cordon trees.

union one may lose the control over growth and fruiting which is so essential for intensive cultivation and which may be obtained by the use of suitable rootstocks. Cordon trees should be planted in a position which will ensure that the scion is on the top side when the tree is bent over (Diagram 2b).

Cordons may be planted at an angle of 45°. In our trials no difference in growth and cropping occurred between trees planted at an angle of 45° and those planted upright and bent to an angle of 45° at the end of the first summer ; whereas the former trees were the easiest to train and manage. A home-made wooden set-square may be used to align the trees on the trellis (Diagram 2*a*). Cordon and dwarf pyramid rows should run north and south if possible. The trees should be planted on the lee-ward side of the trellis to prevent rubbing through the trees blowing on to the wires. Canes may be



Drawings by Eleanor C. Thompson.

DIAGRAM 3.

Diagram illustrating methods of pruning young trees in their first, second and third years to form three kinds of tree for garden use.

tied to the trellis with paper-covered wire, but the trees are normally tied to the canes with soft jute string. We have kept the trees in our trials straight from base to tip instead of bending the tip along the top wire as is sometimes done. When this method is used the trees must be lowered every few years, as shown in Diagram 2*c*, to allow for growth in length.

The effect of distance of planting was tested with cordon trees. Close planting was found to restrict vegetative growth and increase fruiting. The closer of the two distances tried was found to be too close for ease of management and the wider distance wasteful of space with the more dwarfing rootstocks. In gardens where hand cultivation is carried out a suitable distance for cordon apples on M.IX or pears on Quince A or C would be six feet between the rows with from two to three feet in the rows according to the soil. For apples on M.II, three feet in the rows would be needed on most soils. Dwarf pyramids, even on M.IX, should be set out at three feet by six feet in small gardens where hand cultivation is practised. In large gardens or small commercial plantations the distance may be increased to allow for the passage of machinery. It should be remembered, however, that severe root competition due to close planting is one of the means used to restrict vegetative growth and encourage fruiting in the cordon and dwarf pyramid systems and if it is decided to space the trees farther apart either through shortage of trees or a preference for a wider plant, it might be wise to choose the dwarf bush form at eight feet to ten feet apart in both directions.

Since intensive systems of cultivation aim at producing heavy crops of fruit from a relatively small area of land the soil should be in good heart and receive adequate manuring. Restriction of vegetative growth can be achieved by the choice of a suitable rootstock, planting distance, pruning method and cover crop and the good food given by manuring directed into the production of fruit rather than shoot growth. Normally some organic, as well as inorganic, manure is required and on dry soils a mulch of dung or compost may be needed from time to time.

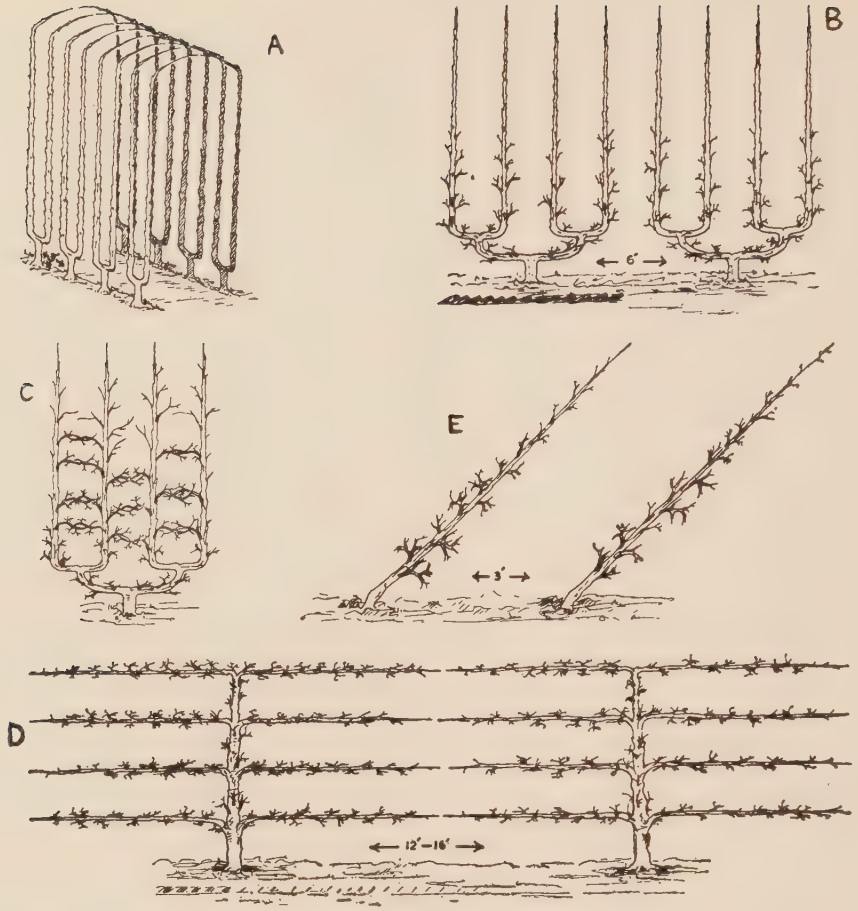
The cultural operation which is often of greatest interest to amateurs is the pruning. Many different methods may be used successfully. Part of the pleasure derived from growing trained trees may be obtained by the choice of a pruning method which suits not only the growth condition of the soil and rootstock-variety combination, but also the particular inclination of the pruner. In the treatment of the lateral shoots as well as in the general build-up of the tree there has recently been a tendency towards simplification of design. Whereas in the past many complicated prunings and pinchings were advised, we have found that we can grow good crops with two or sometimes only one pruning in summer. The simplest form capable of bearing heavy crops is obviously the most desirable. With this aim in view it is possible to achieve grace and simplicity of design in healthy, fruitful trees.

Methods of building up a dwarf bush, a dwarf pyramid and a cordon from a maiden, or -one-year-old, tree are illustrated in Diagram 3, which shows the clean stem of a bush tree, the shrubby habit of a dwarf pyramid and the pillar formation of a cordon. The general shape of some simple forms of trained tree at maturity are illustrated in Diagram 4.

Two methods of pruning the lateral shoots of cordons are illustrated in Diagram 5. The pruning treatments are referred to respectively as methods S and W : S representing summer and W winter, since all the pruning in the first method was given in summer, while in the second a large part of the pruning was carried out during the dormant period, and only a relatively light pruning given in late summer. With method S the pruning was carried out about mid-July and mid-September ; at these times mature laterals from the main stems were cut back to about three inches and laterals from existing side shoots to about one inch. After the trees were five-years-old it was rarely necessary to carry out any pruning in September as very little secondary growth occurred. With method W the trees were pruned in August and again about the end of December. During the first week in August all the laterals were cut to six or seven inches. In December, laterals from the main stem were cut back behind the summer pruning cut to three inches and those from existing side shoots to one inch. With both methods the leading shoot or extension growth of each cordon was not cut either in summer or winter. More fruit was obtained from trees pruned by method S than from those pruned by method W with both Cox and Worcester the difference being more marked with the latter variety.

Two methods of pruning dwarf pyramid trees have been used at East Malling. The treatments are referred to as L and S for convenience, indicating that the lateral shoots were left fairly long with method L and cut shorter with method S. The treatment of the lateral shoots in method S is the same as in the cordon pruning method described under the same letter.

With method L the maiden trees were cut to twenty inches in April and any lateral shoots (feathers) present on the maiden were pruned to about five buds choosing an end bud pointing in a downward or outward direction. The following summer and thereafter any laterals and branch leaders over twelve inches in length were pruned to about five leaves in mid-July. In counting the leaves the cluster of small leaves which often occurs at the extreme base of the shoots was omitted. At the end of the growing season any secondary shoots were cut to their point of origin.



Drawings by Eleanor C. Thompson.

DIAGRAM 4.

Diagrammatic representation of some simple forms of trained trees.

A. Single U espaliers used as an arch.
B. Double U espaliers.
C. Double U espalier with interlacing branches.
D. Horizontal espaliers.
E. Oblique cordons.

With method S the maiden trees were cut to twenty inches in the dormant season. At this time the lateral shoots were pruned to about half their length. The following summer and thereafter the lateral shoots were pruned to three leaves when arising from the main stem and to one leaf when arising from an existing side shoot. If secondary growth occurred the process was repeated in September. This was found to be unnecessary except with very young trees or occasionally with older trees in wet summers. During the dormant season the central and branch leaders were cut to about half their length, the amount removed being adjusted to ensure that the tip of the central leader was higher than that of any of the branch leaders. With both systems the central leaders were pruned in consecutive years to bud pointing in opposite directions in order to maintain a vertical stem. When the trees reached about seven feet in height the central leader was cut to about half its length in May instead of in the dormant season, and from then on any shoots arising from the top of the trees were pruned to half an inch in May to restrict their growth. Branch leaders were cut to half an inch in May when the end of the branch reached a position about eighteen inches from the central stem in a horizontal plane, i.e. when branches of adjacent trees touched along the row. No thinning out of the fruiting laterals was done up to the tenth year but this may be needed in future years. Trees pruned by method L were a little smaller and tended to be more fruitful than those pruned by method S.

If the pruning and general management have led to a good crop the problem of thinning the fruit will arise. We have indications from a preliminary trial on cordon trees that it is safe to thin as early as the end of May. Early thinning has the advantage that the food is directed into the fruits which will

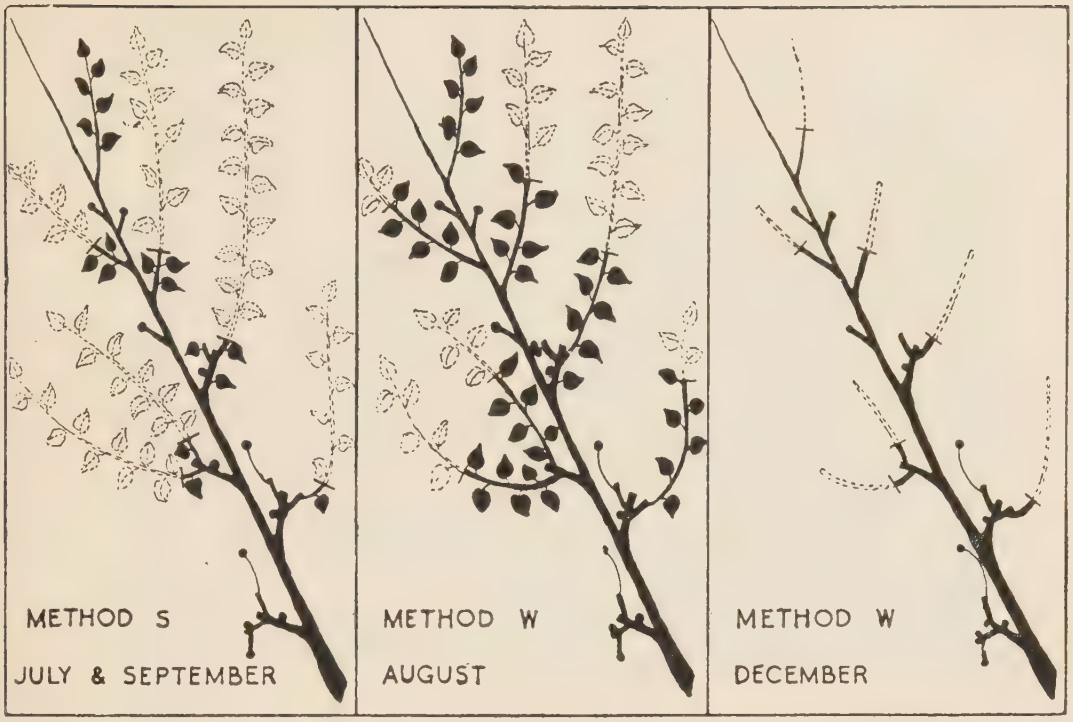


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DIAGRAM 5.

Diagrammatic representation of two methods of pruning cordon trees—S in July and September and W in August and December.

ultimately remain. One need not be afraid of early thinning to one fruit per truss on dwarf trees provided they are well nourished, though occasionally trees in a poor state of health may discard their fruits more freely and leave too few for a satisfactory crop.

Adequate covering with spray materials may easily be given to small intensive trees and it is therefore possible to use spray mixtures which are slightly weaker than is normal for large trees and, in particular, to use those which are free from any risk of damage. This practice is recommended because each individual bud is of greater importance in trees of restricted form than in larger trees. On the other hand a sharp watch must be kept for aphis and other pests which may cripple shoots required to build up the main branch skeleton, especially with espaliers where the branches should be evenly spaced. The development of some pests and diseases will be retarded by the severe pruning by which much of the one-year-old growth is removed. The prevalence of at least one disease, viz. perennial canker *Gloeosporium perennans* may, however, be increased by summer pruning. This disease has not caused any appreciable trouble at East Malling, but has been noted to be severe on summer pruned trees in some districts.

If the trees have been well planted, manured, pruned and carefully but lightly sprayed they may need a slight check in the form of a cover crop at about three years old or a little older. This will also increase the organic matter in the soil. A cover crop containing clover is more suitable than a pure grass mixture which may restrict growth too much. The following mixtures are suitable for garden use.

		oz. per rod.
(1)	Rough or smooth stalked meadow grass	1
	Perennial Rye Grass	1
	Broad Red Clover	1
	Wild White Clover	½
	Sheep's fescue	½
		oz. per rod.
(2)	Rough or smooth stalked meadow grass	2
	Wild White Clover	2

The cover cop may be sown in March or September either over the whole area or as " grass paths " between the tree rows. Once the sward is established it will need to be mown at approximately monthly intervals from April to October. The mowings should be allowed to remain under the trees. A nitrogenous manure such as nitro-chalk should be applied in February at the rate of two lb. per rod to stimulate the growth of the cover crop and assist in feeding the trees.

In conclusion, while it is true that the systems of cultivation described above are not suitable for commercial production on a large scale, they have proved to be of value for garden use and the growing of these small trees can form an absorbing as well as a healthful hobby.

Summary.

A survey of methods of cultivating apples and pears in simple tree forms suitable for the private garden, with special reference to dwarf pyramids and cordons.

Fig. 1.
Dwarf bush tree of " Beauty of Bath " on M.IX rootstock, 11 years old.

Fig. 2.
Cordon trees of five-year-old pears on Quince C.

[face p. 164

FIG. 3.
M. Lorette with some of his fuseaux pears at Wagnonville.

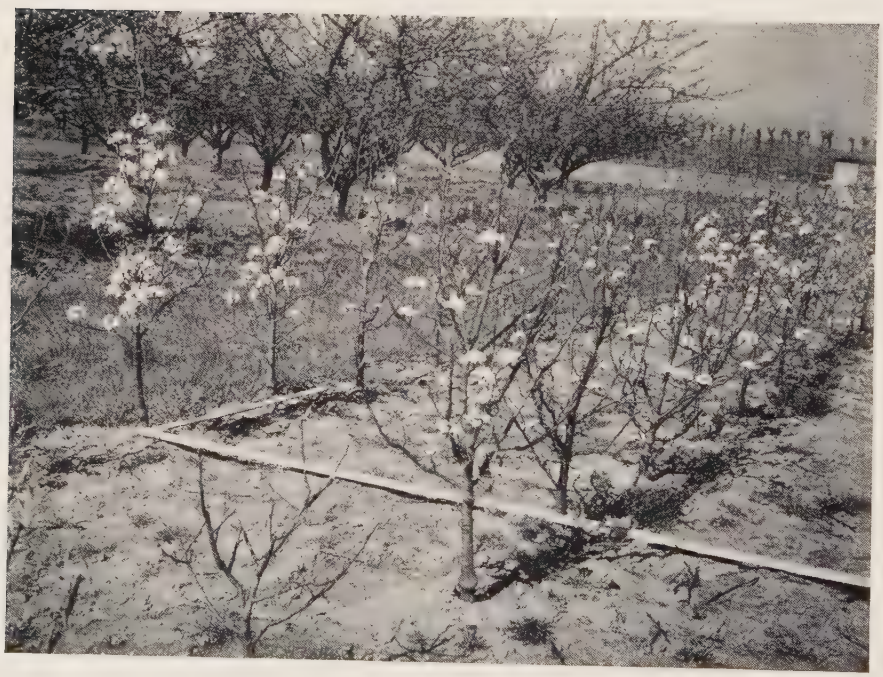

FIG. 4.
Dwarf pyramid or fuseaux pears on Quince C at East Malling Research Station, 4 years old.

WINTER INJURY IN 1947

By IRENA MODLIBOWSKA and H. B. S. MONTGOMERY

The early part of 1947 will long be remembered for the unusually long, cold, snowy period from 22nd January until 10th March. During this period the maximum temperature was below freezing on twenty-five days and as a result the ground was snowbound for seven successive weeks. On the nights of 28th-29th and 29th-30th January, the air temperature at the research station reached zero Fahrenheit. On 23rd-24th February there was again a very cold night with an air temperature of 1° F. During the following day the temperature rose to 38° F. When such near zero temperatures were reached in 1940 serious damage to fruit trees was caused, especially when the temperature of the day following was warm. In 1947 injury was on the whole less severe than in 1940 in spite of the longer period of low temperatures. Notes were kept of the damage to fruit trees that was observed at this research station during 1947 and they form the basis of this bulletin. It is possible, however, that further injuries may show up later. The type and extent of injury differed with the kind of fruit and even with variety, rootstocks, treatment, etc.

Rootstocks in Layer Beds.

The apple stocks M.I, II, IV and VII were all much affected by pith-staining extending the whole length of the shoots, M.IX was less affected and M.XVI scarcely at all. Quince stocks were more affected, A suffering more than C. Of the three plum stocks examined Common Plum was most affected, Common Mussel least, and St. Julien A was intermediate.

Apples.

Shoots. The first sign of injury was seen as a discoloration of the pith at the tip of the shoot. In severe cases the discoloration was a deep brown and extended right down to the base of the shoot. The pith appeared most affected at the nodes, though the pith of the buds seemed unaffected. This injury had little or no effect on the behaviour of the shoots and some that were used as scions for grafting behaved quite normally.

Miller's Seedling showed more pith-browning than Cox's Orange, Early Victoria showed less and Ellison's Orange hardly any. Shoots on trees that cropped heavily in 1946 were less affected than those that had not cropped.

Spurs. Spurs are complex organs composed mainly of swollen *bourses*, which have already borne fruit and *dards*, short shoots each terminated by a *fruit-bud*. Injury to spurs showed in the *bourses* first, in the form of pith discoloration. Injury to *fruit-buds* ranged from dwarfing and killing of the styles (which became apparent when the flowers opened) to killing of the whole buds.

Beauty of Bath, Bramley's, Cox's Orange and Miller's all showed some pith-browning of the bourses, whereas Barnack Beauty and Worcester did not. Trees of Miller's Seedling that cropped heavily in 1946 had much more injured bourses than those that did not crop ; thus the cropping affected susceptibility in opposite ways in shoots and in spurs.

Branches. The bark on some branches of Early Victoria that were severely pruned was completely killed, becoming brown, spongy, soft and watery, and the outer layers peeled off as a papery layer. The bark died back in long narrow strips from below the pruning cuts, usually down to the crotch. No injury was observed on the branch above the one cut off. A similar injury to bark was found on a few Bramleys, also pruned back hard. Here the damage was more localized to about one foot below the wound. Papery bark was less common at East Malling after the winter 1946-47 than it was after 1939-40.

Trunks. The most frequent form of injury to trunks was in the form of vertical cracks or splits in the bark from a few inches in length to several feet. No frost cracks occurred after the zero temperature in January but after the night 23rd-24th February when the temperature fell down to 1° F., the day temperature rose to 38° F. and cracks were found on many trees on 24th February and during the following week. These cracks started under the sacking band that protected the tree where it was tied to the stake and observations showed that the cracks continued to extend, especially when the fluctuation of temperature was high. Cracking in 1947 was always accompanied by lifting of the bark around the crack (Fig. 1). Lifting of the bark without cracking also occurred but this is less easily noticed and usually becomes joined again by natural callus formation. Examination of freshly

cut cross sections of stems shows this callus, the so-called frost ring, as a brown line and such lines were clearly visible in the trunks of nineteen-year-old Cox trees in the annual rings for 1939-40 and for 1946-47. They are most pronounced immediately below the crotch in places where one could hear the hollow sound by tapping on the bark. Cracking and bark lifting appeared to have no adverse effect on growth or cropping if infection by canker, silver leaf, etc., did not occur. Lifting of the bark without cracking is safer in this respect as there is no open wound for the infection.

Splitting occurred chiefly on Cox on M.IX, in one twelve-year-old plantation. No new cracks were found on similar trees, fourteen years old, on a plot where many trees split in 1939-40. Only a few trees split in an older plot, nineteen years old. Cox suffered where interplanted Worcester showed no injury. Cracking bore no relation to the crops borne in the preceding year but was linked with the size of the trunk, i.e. the thicker the trunk, the more the cracking, other factors being equal.

Most of the frost cracks were nailed as a routine treatment, but a few were left for observation. Bayonet tacks $\frac{2}{3}$ inch long with $\frac{3}{32}$ inch diameter head were put in two rows along each side of the crack. The first row was put along the line of demarcation between lifted and normal bark, the nails being two inches apart. The second row was put along the edges of the crack, about 1 inch to $1\frac{1}{2}$ inches apart. The whole wound was then covered with vaseline.

This nailing reduced the gap between the lifted bark and the wood, checked drying and thus allowed the callus to join the bark back onto the wood. In most cases the split was almost completely healed at the end of the season, though in some cases thickening of the bark pulled the bark over the heads of the nails, thus delaying complete healing. This happened most where small headed nails were used. Where nailing was not done the lifted bark curled back from the wood, exposing a large area of wood to drying (Fig. 2). This wood died and afforded an entry place for decay and disease.

Pears.

Shoots. Dark brown to black discoloration of the pith of young shoots was widespread, in severe cases being associated with darkening of the bark and killing of buds.

Spurs. All varieties have shown discoloration of the pith of spurs, which sometimes spread to the wood and outer tissues. The most sensitive place was apparently about $\frac{1}{4}$ inch below a fruit-bud. Here there was usually a very dark line less than $\frac{1}{8}$ inch wide, with the pith above the line darker than that immediately below it.

Bourses that had borne fruit the previous year had the darkest pith, particularly those at the tip of a shoot that carried secondary fruits ; these were very common on Dr. Jules Guyot. This injury had no obvious effect on cropping.

Injury to fruit-buds was common on pears. Dwarfing and killing of the style was seen on the king flowers of Bellissime d'Hiver growing on the North wall of the N.F.U. building. Killing of individual flowers, one or more per cluster, was common in the pear plots on Egham Field, but caused no loss of crop and was not sufficient even to serve as a substitute for manual thinning. One variety, Orange Bergamot, suffered the loss of complete flower-buds and even some leaf-buds with resultant loss of crop. In the Bradbourne Gardens the dwarf pyramids were severely injured, almost all the fruit-buds being destroyed. Doyenné d'Eté, Laxton's Superb and Glou Morceau suffered most, while Durondeau, Winter Nelis and Conference escaped with more flowers, though even they failed to carry a crop.

Trunks. The severe winter not only killed the pear fruit-buds in the Bradbourne Gardens but it caused also a more permanent damage to the three-year-old cordon and pyramid trees, mainly to their trunks and main branches. This damage became most obvious during the hot spell in June when the foliage of many trees began to wilt and the tops of some died (Fig. 3). The injury occurred on that part of the trunks that was above the snow level, i.e. about ten inches above the ground. The whole bark and the outer layers of wood were completely killed in this region. The injury gradually diminished towards the top which began to develop normally until shortage of water during the hot and dry period caused it to collapse suddenly. Laxton's Superb, Beurré Superfin and Doyenné d'Eté were most affected, while Conference and Fondante d'Automne proved most resistant. The damage was more severe with trees on Quince C than on Quince A rootstock. It is interesting to note that the effect of a stock upon the resistance of a variety may thus be quite different from the resistance of the unworked stock in the nursery. Strong shoots grew up from the living base of the trunks of most of these trees and suitable ones were trained to replace the dead tops which were cut off. Branches above the snow line were often partially or completely frost ringed at their bases and some of them gradually died during the season. This was very striking on the arcures where some of the upper-arched branches had to be removed owing to the winter killing. In Comice the killing of wood-buds resulted in the formation of groups of slender spindly late shoots.

Plums, Cherries and other Stone Fruit.

Very little injury was found on plums, except for pith-browning at the tips of young shoots and the killing of a small proportion of fruit-buds.

On cherries, as with pears, a whole range of injury to fruit-buds was observed. In general the damage, which was light, was confined to a few varieties and the crop was not affected.

Those most affected were Caroon, Newington Black and White Heart. Emperor Francis, Noir de Guben, Noir de Schmidt, Rodmersham Seedling and Waterloo were all less injured. Some of the early flowers of Baumann's May B were lacking styles killed in winter when very small (Fig. 4).

In general, winter frost damage was always associated with some gumming on the affected trees.

Among sour cherries injury to fruit-buds was observed in Kentish Red, Flemish Red and also in the Morellos.

Injury to peaches and apricots was more severe. The crop was greatly reduced through the killing of fruit-buds, only some, in the upper part of the tree, escaping damage. With apricots, leaf buds and even whole shoots were killed, Royal and Large Early suffering very severely. Breda showed the least injury.

Small Fruits.

Loganberries suffered heavy losses, many buds being killed. Where the cane was sound new buds developed after a short delay but many canes were killed completely or so severely injured that they died later during the summer drought. An interesting difference was observed in a training trial, where the new cane of some plants was trained along the bottom wire and of others along the top wire. The most severe injury occurred on those canes trained along the bottom wire.

Blackberries are usually regarded as very hardy but the Himalaya Giant Blackberry in the Bradbourne Gardens was killed to ground level. Merton Early (*Rubus nitidioides*) also suffered a great deal of cane killing.

Raspberries also suffered heavily. In the case of Norfolk Giant up to 50 per cent. of the canes died during the season. This resulted in a great reduction in the crop. It is interesting that no killing was observed after the winter of 1939-40.

A brief questionnaire on winter injury was sent to a number of selected growers and to the officers of the N.A.A.S. and thanks to their most helpful co-operation information has been collected from most of the main fruitgrowing areas. Some of the more interesting results of this survey are given here.

Injury was reported from the following counties—Kent, Essex, Surrey, Sussex, Hants, Isle of Wight, Oxford, Cambridge, Herts, Bucks (slight only), Suffolk, Norfolk (slight only), Worcester, Hereford, Warwickshire, Cheshire, Northumberland and Durham. Replies from the South-West and from Lincolnshire reported that no injury had been observed.

Splitting of the bark of apple trunks has been noticed in most places, mainly on Cox, but also occasionally on other varieties. In Cambridgeshire splitting was much more extensive in 1946-47 than in 1939-40. Where the splits have been carefully nailed as recommended by Dr. Filewicz in 1940 healing has usually been excellent. In most cases the splits were small and no remedial measures were taken. Trees with split bark grew and cropped normally and appeared to suffer no ill-effects, so long as the tree did not become infected by disease through the split.

Injury to the bark of the main limbs has been noticed on occasional trees up and down the country and in some cases affected branches died back later. Bramley's Seedlings were more damaged than other varieties. Some trees frameworked the previous season were much more injured than adjoining ones that were not grafted. Some of the frameworked trees died during the summer, others lost their horizontal branches while the upright middle branches grew vigorously in 1947. Bramley's Seedling trees cut back for grafting during the winter 1946-47 and then top-worked in spring, showed in autumn a great deal of papery bark on branches, and on some trees large patches of dead bark could be peeled off easily from the base of the trunk on its southern side. The adjacent, ungrafted Bramley's Seedlings did not show much frost injury.

The loss of 300 apple trees (Cox's Orange Pippin and Worcester Pearmain) was reported from an orchard growing in a frost pocket in Hampshire.

Replies from farms surveyed for winter frost damage in 1940 showed that the loss was not necessarily confined to those trees that died during the season, but was spread over a period of several years during which branches and whole trees died. Those areas most affected in 1940 were not much damaged in 1947, except for the low lying Marden district.

Severe damage to Conference pears on Quince A was reported from Cambridgeshire, the trunks of most of the trees in a ten-year-old plantation splitting on the South-West side. The bark was nailed

down and healed well. Injury to shoots, spurs and buds was also noted. In East Kent, Catillac pears suffered severely, almost all the fruit-buds being killed. In the Weald, damage to pear fruit-buds was extensive.

The shoots on quince stool-beds in Canterbury were killed down to the snow level and in Hampshire, where they were unearthed at the time of the frost, they were killed completely.

With plums, loss of fruit buds seems to have been fairly general, especially with Cambridge Gage, Giant Prune, Czar and Victoria, though in some cases it has been difficult to separate this injury from that due to petroleum oil sprays.

Where loganberries and blackberries were trained on wires in the open, loss of a proportion of the fruiting cane was general. Reports of damage to raspberries, and in particular to Norfolk Giant, were received from several places in Kent and Sussex. In some cases Norfolk Giant was affected while adjoining Lloyd George remained uninjured.

Summary.

Brief notes on injury to fruit trees observed after the long, cold, snowy period from January to March, 1947.

Fig. 1.

A frost crack on the day of appearing. The white line delimits the area of bark lifted from wood.

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FIG. 4.

Winter frost damage to cherry flowers. Note killed styles in the bottom flowers.

A FOG IN MARCH—A FROST IN MAY?

By A. P. PRESTON

This countryman's saying seems prevalent in the home counties and especially in Kent where any forecast as to the likelihood of late spring frosts is of considerable value to a fruitgrowing area. At East Malling, meteorological records have been kept since August, 1914, and in the early years temperature, rainfall and sunshine records only were recorded. Since 1923, however, more complete records have been made under the Agricultural Meteorological Scheme, so that it is possible now to examine the data for the presence or absence not only of May frosts but also March fogs over a period of twenty-five years. This note covers the result of such an examination which was made recently.

What is a Fog ?

It was necessary first to determine what would be considered a fog by a countryman, at what period of the day it would be noted by him and where the dividing line is between fog and early morning mist.

At this station, which lies on a gentle northern slope, observations for the presence of fog are made covering the period from midnight to 9 a.m. (G.M.T.), at 9 a.m. and from 9 a.m. to midnight. So that it is possible for fog to be recorded at any one, two or all of these periods each day. Meteorologists recognize High Fog, Wet Fog and Ground Fog. The first occurs near industrial centres, where heavy smoke-laden clouds cut off practically all daylight, but obviously this does not comply with the conventional definition of fog which is a " diminution in the transparency of the atmosphere due to suspension in the lower layers of small liquid particles ". Wet fog indicates one in which water is deposited copiously on exposed surfaces. Finally, Ground Fog indicates a fog that does not exceed the height of a man, and here it is important to remember that fog in a valley seen from a station on a higher level cannot be considered as ground fog. Intensity of fog, recorded at these periods, is noted by either a small or capital letter thus : f = fog ; F = thick fog. Continuity of fog is indicated by a repetition of the small or capital letter thus : FF = continuous thick fog. Selected objects, at specified distances, used in estimating visibility, give an observer a good indication of fog intensity.

Frost and Fog Records at East Malling.

The number of March fogs and May frosts occurring each year was extracted from the meteorological records during the period 1923 to 1947 inclusive, but the years 1924 and 1937 had to be excluded from the summary due to missing data caused by broken thermometers.

The occurrence of frost was recorded when the minimum thermometer in the screen registered a temperature below 32° F. during the twenty-four hour period ending 9 a.m. G.M.T. Ground frosts were not considered in this enquiry.

In assessing the presence or absence of fog, considerable care was needed to include all possible times at which fog could occur, for the saying does not specify a whole day of fog, morning fog or evening fog, but merely " fog in March ". Two summaries were made of the available fog records as follows :

Summary 1. This includes fog recorded before 9 a.m., at 9 a.m. and after 9 a.m. on any one day in March.

Summary 2. This includes fog recorded before 9 a.m. *or* at 9 a.m. *or* after 9 a.m. on the previous day.

This second summary therefore, takes into account evening fog or early morning fog as distinct from the more continuous type of fog recorded in the first summary.

The number of screen frosts occurring in May together with the number of March fogs summarized in two categories, is shown in the accompanying table, covering twenty-three years' records. This table shows clearly that the recent late spring frosts occurring in May (1935-38-41-44) followed the occurrence of fog in the preceding March, although the exact number of frosts does not seem related to the number of fogs. But the dictum failed in the years 1926 and 1939 when screen frosts occurred in May without fogs being recorded in March, a considerable failure from the point of view of a fruitgrower who would not have been *expecting* a May frost without a March fog.

From the table it is seen that during the twenty-three years under review there are two years in which screen frosts occurred during May without fogs in the preceding March, eight years when fogs occurred in March but in which no screen frosts were recorded in May, and twelve years when fogs in March were followed by screen frosts during May. These records were submitted for statistical

analysis and it appears that the number of foggy days in March, on either of the two definitions of fog considered in the table, is not correlated with the number of screen frosts recorded in May. Had there been a small correlation, it would have shown up better had records been available over a longer period, say fifty or eighty years. It is apparent, however, that if a definite and fairly large correlation between fog in March and frost in May cannot be shown over a twenty-three year period, then there is little chance of truth in this countryman's saying within the given interpretations of March fog and May frost used in these summaries.

The writer would like to express his thanks to Professor Brunt of Imperial College, and Mr. Giles Tuker of Danbury, Essex, for their interesting private communications upon the subject ; also to his colleague Mr. J. Taylor for carrying out the statistical analysis, and to Mr. H. C. Chapelow, who until 1944 was responsible for recording meteorological phenomena at this Station.

Summary.

An examination of the meteorological records of the Research Station failed to support the saying that fog in March is followed by frost in May.

Summary of Fogs in March and Frosts in May at East Malling

Year.	Number of March Fogs. Summary. 1.	Summary. 2.	Number of May Frosts.* Screen temp. below 32° F.
1923	0	1	0
1925	0	0	0
1926	0	0	1
1927	0	1	4
1928	0	1	1
1929	1	5	3
1930	1	2	0
1931	0	2	0
1932	0	2	1
1933	1	3	0
1934	0	3	0
1935	0	1	2
1936	3	6	1
1938	2	6	3
1939	0	0	1
1940	0	1	0
1941	4	8	7
1942	1	6	4
1943	4	11	0
1944	2	6	5
1945	0	2	2
1946	0	5	2
1947	1	3	0

* The majority of these May frosts were light and caused negligible injury to fruit, in fact the only years in which they caused loss of crops were 1935, 38, 41 and 44.

EAST MALLING RASPBERRIES

By A. C. PAINTER

The following new raspberries raised at East Malling by N. H. Grubb have already been described by him in some detail elsewhere (see References). It is thought, however, that there is room for abbreviated descriptions confined to some of their salient features.

It is not yet possible to make a final assessment of their general suitability as their behaviour differs to some extent according to the locality in which they are grown. The following notes, based largely on their behaviour at East Malling, are intended as a guide to the chief characteristics of each.

Malling Enterprise. (33/132. From a cross between Preussen and an earlier seedling. Formerly known as Seedling " E ".)

Very vigorous, often reaching a height of seven feet even on poor soil. Canes stout, erect or nearly so at base, becoming more nearly horizontal higher up, resembling Norfolk Giant in habit. On some soils may produce too little cane, like its parent Preussen. Glabrous (i.e. not hairy), turning a dark reddish purple later in season. Spines dark, conspicuous ; few and small except on young plants and lower parts of canes of older plants. Under favourable conditions crops heavily.

Fruit very large, roundish, firm. Size well maintained throughout season. Colour moderately bright red, brighter than Norfolk Giant but not as bright as Lloyd George at its best. Sometimes a little dark when fully ripe, but much less so than Lloyd George. Flavour good. Favourably reported on for canning. Ripens about mid-season over rather a long period.

Susceptible to Cane Blight, though probably less so than Newburgh.

Malling Landmark. (34/42. From a cross between Preussen and Baumforth A. Formerly known as Seedling " L ".)

Very vigorous, often reaching a height of 7 feet, and sometimes more. Canes abundant, stiff and almost erect, glabrous or nearly so, turning a bright red to reddish brown later in season. Spines numerous, large and stiff, tinged, inconspicuous. On many soils crops outstandingly heavily.

Fruit large to very large, almost round, usually rather soft. Size well maintained throughout the season. Colour light bright red, with little or no tendency to darken even when fully ripe. Does not always part easily from plug. Flavour good, slightly acid. Usually too soft for anything but jam. Ripens late, but not quite as late as Norfolk Giant, with a long picking season.

Resistant to Cane Blight, but susceptible to Cane Spot and apparently to " Dwarf ". Thought likely to prove more satisfactory in the south than in the north.

Malling Notable. (32/163. From a cross between Preussen and Lloyd George. Formerly known as Seedling " N ".)

Vigorous, reaching a height of six to seven feet in favourable conditions. Canes fairly abundant, nearly erect at base, arching to a horizontal or slightly drooping position higher up. Glabrous ; turning to reddish purple later in the season. Spines dark, numerous but small. Leaves near growing tips distinctly reddish. As a rule crops heavily.

Fruit large where conditions are favourable, roundish to conical, usually firm. Colour fairly bright, not turning very dark when fully ripe. Generally plugs easily. Flavour sweet but not markedly good. Season second early to mid-season.

Whilst not outstanding at East Malling has done very well in parts of Scotland and Northern England.

Malling Promise. (51/79. From a cross between Newburgh and an earlier seedling.)

Vigorous, reaching six feet or more even on poorish soil. Canes abundant, especially during first two years, nearly erect, glabrous, turning brownish later in season. Spines rather numerous, sometimes dark, sometimes tinged. Heavy cropper, sometimes producing nearly a full crop at eighteen months from planting.

Fruit very large, somewhat conical, firm. Colour fairly bright, but sometimes becomes dull in hot dry weather. Does not darken appreciably when fully ripe as do many other varieties. Flavour good, probably better than that of any described here except Seedling " G ". Season early. Said to be fairly satisfactory for canning.

Possibly the most promising of the new seedlings raised at East Malling.

Seedling " G ". (32/166. From a cross between Preussen and Lloyd George.)

Very vigorous, frequently reaching a height of eight feet. Canes fairly abundant, erect or nearly so at base, bending over somewhat near the tip. Hairy, turning a dull dark reddish purple later in the

season. Spines small, dark and conspicuous ; not numerous except on lower parts of canes. Once established crops heavily.

Fruit large to very large, rather long conical, firm except when over ripe. Size fairly well maintained to end of season. Colour very bright, equal to Lloyd George at its best, with much less tendency to become dark even when fully tipe. Flavour good to very good, probably the best of the East Malling seedlings in this respect. Ripens mid-season or a little later.

Owing to its good quality considered suitable for garden culture.

Seedling " J ". (33/54. From a cross between Preussen and an earlier seedling.)

Vigorous to very vigorous, usually attaining a height of six to seven feet. Canes abundant, rather stiff and almost erect. Glabrous ; turning bright red or purplish later in season. Spines inconspicuous, tinged ; few and small except on young plants and lower parts of canes of old plants. Crops heavily.

Fruit large to very large, conical, firm. Size apt to fall off as season advances. Colour bright red, brighter than Enterprise, but with slightly more tendency to become dark when fully ripe. Fruit very easy to find, being seldom hidden by foliage. Flavour fair to good, sweetish. Reported suitable for canning. Ripens early mid-season, immediately after Seedling " K ".

Somewhat susceptible to Cane Blight, though less so than Malling Enterprise.

Seedling " K ". (33/115. From a cross between Preussen and an earlier seedling.)

Vigorous to very vigorous, reaching six feet or more on poor soils. Canes abundant and almost erect, bending slightly towards the tips. Glabrous or nearly so, turning a dark reddish purple later in the season. Spines tinged, inconspicuous ; few and small except on young plants and lower part of canes of old plants. Crops heavily.

Fruit large, sometimes very large, short conical, firm. Size apt to fall off as season advances. Colour moderately bright red, similar to that of Enterprise or a little brighter, with slightly more tendency to become dark when fully ripe. Flavour fair to good, sometimes rather insipid. Ripens early mid-season.

Seedling " M ". (32/138. From a cross between Preussen and Lloyd George.)

Vigorous to very vigorous, reaching a height of six to seven feet in conditions that suit it. Canes moderate in quantity and fairly erect, bending over at the tips ; turning rather dark purplish red late in season. Spines conspicuous, dark, small and not very numerous. Crops well.

Fruit large, slightly conical, firm, of good colour and appearance. Flavour fair, better than Norfolk Giant ; sweet. Ripens mid-season.

Whilst not outstanding at East Malling has done well in parts of Scotland and North of England.

Summary.

Abridged descriptions are given of new raspberries raised at East Malling by N. H. Grubb and already described by him elsewhere.

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SOME IMPRESSIONS OF NEW ZEALAND RASPBERRY GROWING

By C. H. CADMAN

Some months ago it was announced in the press that a stock of Lloyd George sent over to this country from New Zealand had been found to be free of known virus diseases. This is one in a chain of events following the visit of a delegation of the Farmers' Unions of the United Kingdom to the Dominion in 1944-45 which has, in the eyes of British growers, recently put the New Zealand raspberry industry on the map.

Last winter, as a result of an invitation from the New Zealand government to East Malling Research Station, and by arrangement with the Agricultural Research Council, the writer was enabled to spend three months as guest of the Dominion Department of Agriculture investigating Dominion raspberry problems in collaboration with members of staff of the Horticulture and Plant Diseases Divisions.

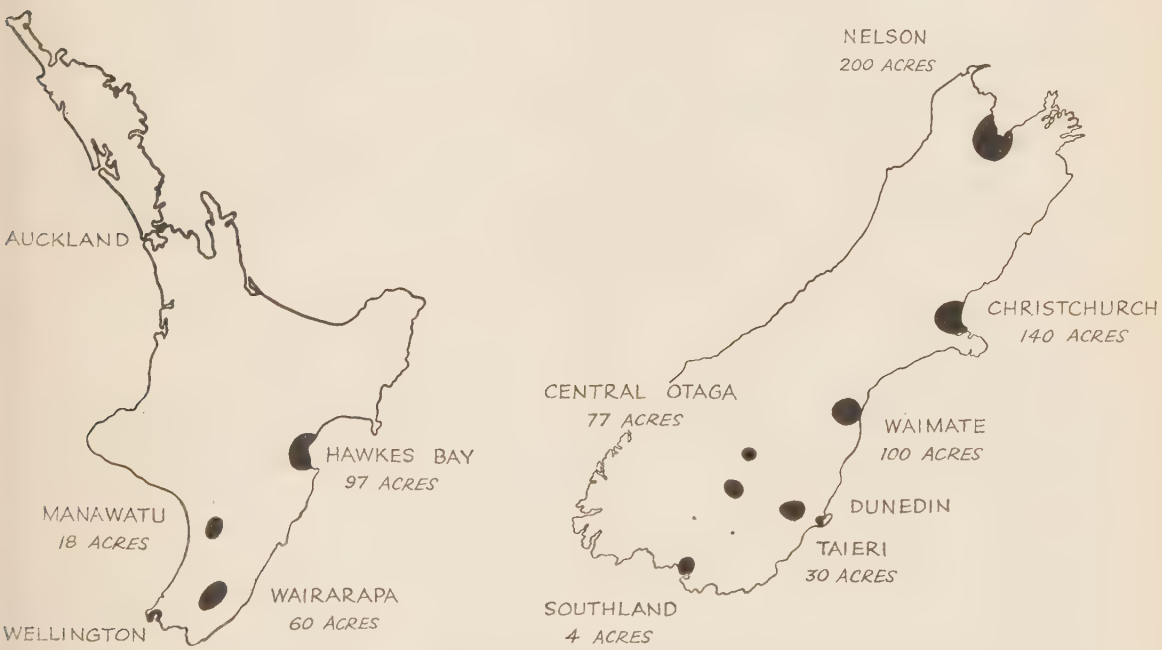

FIG. 1.—Distribution of areas and acreages of raspberries in the North and South Islands of New Zealand.

New Zealand is so often described as being, climatically, the Britain of the Southern Hemisphere that the important fact that the whole of the Dominion is nearer the equator than any part of Britain tends to be overlooked. Around Auckland, which is on a similar latitude to Naples, and as far south as Hawkes Bay, subtropical and citrus fruits are grown; whilst the important pip and stone fruit areas of Nelson and Central Otago are on a level with Madrid and Southern France respectively.

Acreage under Soft Fruits.

The area under soft fruits occupies a comparatively small proportion of the total fruit acreage (1,382 out of about 20,000 acres) and the output is, at present, consumed entirely within the Dominion though, in the past, a small tonnage of soft fruit pulp has been exported overseas.

Raspberries are the most important of the soft fruits grown but the industry has experienced a decline in recent years and there is a drive in progress to step up production and acreage to meet the unsatisfied demand particularly of the large North Island cities.

About three-quarter of the acreage is grown in the South Island, principally in the hinterland of Nelson in the northern tip of the South Island and around Christchurch and Waimate in the Canterbury plains with smaller areas in Central Otago and further south at Dunedin and Invercargill.

In the North Island the Wairarapa valley north-east of Wellington is a raspberry growing area of some thirty years' standing whilst the Manawatu district on the west and the Hawkes Bay area on the east coast are developing rapidly. Successful cultivation in the north is limited by, among other things, the dry summer conditions and warm winters.

Varieties of Raspberries.

The varieties grown vary from one area to another according to the consumer trade and local climatic conditions. Stocks are liable to vary in purity and there is a certain amount of confusion in varietal names. One of the main projects under way at the Dominion Horticultural Station, Levin, is to straighten out this situation.

Nelson and Christchurch are the only two areas catering intensively for the jam manufacturer. Red Antwerp, probably synonymous with one of the old British varieties of that name, is the favourite of Nelson growers on account of its good jamming quality and its well-defined cropping season which ends before work on the tobacco harvest is in full swing. The major part of the Christchurch acreage is owned by a jamming firm which has planted the variety Great American almost exclusively.

Apart from these outlets there is an extensive trade in fruit for domestic consumption retailed as dessert fruit in punnets or jam fruit in 12-15 lb. cans. A variety variously known as Fillbasket or Superlative is widely grown for the fresh fruit trade and produces good crops of high quality berries. Lloyd George is grown to some extent in most areas but opinions on its usefulness are divided. In quality, it is generally held to be inferior to Fillbasket.

Various other British and American varieties have been imported from time to time and are still grown but the above four are the only ones of real importance. One outstanding feature of these four varieties in New Zealand is the abundance and quality of their second crop or autumn fruit. This was still on the market when the writer left Wellington at the end of March ; picking started well before Christmas in the North Island this year.

Soils.

In a short space it is difficult to give an adequate picture of the influence of soil conditions on New Zealand fruit growing and on raspberry growing in particular.

Geologically speaking, New Zealand is a youthful country. In place of the rounded contours of hills and valleys familiar to us at home one is struck by the sharp relief of mountainous country—the result of water erosion. Huge rivers meandering for miles through such broken country have spread their silt over the valleys and plains with each successive flood. These processes are still in active progress at the present time and whilst they have led to the formation of areas of highly fertile land these river-deposited soils are notoriously variable ; in many areas one can, sometimes in a matter of yards, find every gradation between shingle and deep fertile silt.

Consequently, great care has to be exercised in the choice of land for raspberry growing. With few exceptions, the most productive gardens are located on pockets of fertile soil adjacent to existing or old river courses. On these sites, the greatest hazards are the maintenance of the initial soil fertility and the avoidance of waterlogged conditions to which raspberries are extremely sensitive.

Humus in the form of animal manure is rarely available in quantity and large amounts of straw can be obtained only from the wheat growing area of the Canterbury plains. Surface mulching is therefore an expensive business. In some districts, cover cropping is extensively practised, using blue lupins or peas and oats grown between the rows and turned in by rotary hoe.

The most readily obtainable manure is blood and bone ; this is widely used on its own but a balanced mixture with phosphate and potash is officially recommended.

Irrigation and Shelter.

In districts where the summer rainfall is low provision has to be made for irrigation. Overhead pipe lines were seen in action in Hawkes Bay and Wairarapa gardens, but in Canterbury, plantations are serviced by irrigation and are flooded periodically during the growing season. Care has to be exercised in the use of water since, on poorly drained soils, irrigation may lead to serious deterioration of the crop.

New Zealand is sometimes described as one of the windiest countries in the world, and in this Dominion growers have a problem more or less unknown to us at home. To plant without making

provision for adequate shelter is, in the majority of areas, to court disaster. At Christchurch, in addition to marginal shelter belts, growers were using green poplar stems for end posts to the rows. On rooting these provide shelter which grows with the plantation.

Planting Systems and Cultivation.

Three main types of planting systems are in vogue. Christchurch growers use the post and wire hedge system familiar to British growers ; the rows being spaced at six feet with eighteen to twenty-four inches between stools and the canes tied to, or clipped in by, pairs of wires and topped at four feet.

The self-supporting hedge which dispenses with posts and wires is widely used in the Wairarapa district. The planted rows are allowed to fill out with young canes until a solid hedge is formed about one foot wide, the individual canes being spaced at about six to eight inches. This system does not seem to have much to recommend it since the fruiting canes have to be severely cut back to three to three and a half feet in order to give them sufficient strength to carry the fruit. The fruit tends to be hidden by the young canes and picking is therefore slow.

In Nelson and elsewhere the individual plant or " hill " system in one of its forms is used. When properly managed it appears to be a very neat method though its efficiency depends a good deal on the habit of the variety. In general, four to eight canes are planted together in holes spaced six feet apart both ways or six feet by four feet. This spacing should permit cultivation both ways throughout the life of the plantation, the individual stools being strictly confined in size and allowed to carry an optimum of eight to twelve canes per stool.

In one variant of this system the young canes are loosely gathered into a bunch with binder twine and topped at four to four-and-a-half feet. This works particularly well with a variety like Red Antwerp which has a stiff and erect habit of growth, but varieties of floppy growth, such as Lloyd George, tend to become unmanageable. In Otago, the fruiting canes are tied to a strong stake driven into the centre of the stool and are not topped.

Particularly where growth is vigorous, both these methods are open to the objections that the young canes crowd out and shelter the fruiting canes and impede air circulation ; on large stools, both picking and spraying are hampered.

The most efficient variation of the hill system is somewhat similar to the practice of Clyde valley growers in Scotland. The number of young canes per stool is limited to six to ten, and these are bunched at about six to eight inches from the tips, bent over and tied to the base of the next stool in the row. Some growers take half the canes each way and tie the tips in the overlapped position, the fruiting canes thus forming arches between adjacent stools, streamlined to the direction of the wind.

These tie-over variants of the hill system merit serious consideration by British growers since they materially reduce cost of production without impairing efficiency. The growing of stools in individual hills reduces hand labour considerably as well as dispensing with the permanent post and wire fence. The methods of training allow of easy access for picking and the fruit is free of shade from young canes. If necessary, the new growth can be loosely bunched during the growing season and can be sprayed without interfering with the fruit.

There is, at present, no basis on which to compare the efficiency of these various planting systems so far as cropping goes. *A priori*, one would think that those involving hard pruning must reduce the productive capacity of the canes.

For summer cultivation, eight- to twelve-horsepower rotary hoes are much used ; larger tractors of the Bristol and Farmall type and horses are uncommon. North Island growers do little more than surface cultivation all the year round but many growers in the south follow the same system of winter ploughing and deep cultivation as British growers.

Cropping and Marketing.

In the 1947-48 season, no one could fail to be impressed by the vigour and growth of cane and the high level of production of the best of the raspberry plantations in the Dominion. Forests of cane eight to nine feet high and yields of two to three tons or more per acre were by no means exceptional.

Plantations more than three years old account for about two-thirds of the total acreage, and these include several gardens of thirty and more years standing which are still yielding profitable crops.

Of fruit picking problems, Dominion growers have just as large a share as British growers, especially since many of the raspberry districts appear to be remote from local sources of labour and pickers are, if anything, more demanding in their requirements.

Dessert fruit is picked into and marketed in one pound punnets whilst jam fruit for the retail market is distributed in twelve pound returnable buckets or tins. In the Nelson province fruit supplied to jam manufacturers is transported in barrels to the factories for pulping. No fruit pulping is carried on by growers themselves.

In the more important raspberry growing districts producers have formed local associations, of which the most fully organized is the Nelson Raspberry Marketing Committee. Maximum wholesale and retail prices for the season's fruit are revised and fixed annually by the Price Tribunal. Growers have been quick to appreciate the value of a close co-ordination of interests and look forward to a Dominion-wide organization linked with the New Zealand Fruitgrowers' Federation.

Insect Pests and Fungus Diseases.

Of factors which tend to reduce production in New Zealand the two most important appear to be unfavourable soil conditions and damage by the native bud-moth (*Carposina adreptella*). The caterpillars of the latter are active for the best part of twelve months ; growing tips and a proportion of buds on the young canes are destroyed before the canes mature. The grubs frequently attack and lodge in the ripening fruits but New Zealand growers are free from the scourge of Raspberry Beetle.

Damage to roots by grass grubs (the larvae of *Odontria zealandica*), which are somewhat similar to chafer grubs, is also a problem in some areas.

Of fungus diseases, Cane Spot and Spur Blight are widely distributed as in this country but the active interest in spraying programmes and machinery for small fruit work bid fair to bring both these diseases and bud-moth under adequate control.

Sprays and Spraying Machinery.

Experiments carried out by the Plant Diseases Division (Scientific and Industrial Research Department) have demonstrated the practical value of spraying in increasing production. Dominion growers follow a five-spray schedule with rates of application up to 5-600 gallons-acre which would shock a proportion, at any rate, of British growers.

Though there is, perhaps, a wider range of spraying machinery suitable for small fruit work available than in Britain, the mechanical problems of effecting a compromise between efficient performance and economic working are just as pressing. Spraying attachments with tanks of 25 gallons capacity fitted to small-horsepower rotary cultivators are reasonably efficient on small acreages but much time is wasted in constant refilling of the spray tank.

One grower in the Nelson province had a useful portable outfit made by the Bean Sprayer Co., California, towed by a Bristol tractor. With a tank capacity of 80 gallons, and an 8-nozzle upright tail boom powered by a 2 horsepower pump, this unit put up a creditable performance and appeared to be easily manoeuvered.

A very neat adaptation of a Farmall B tractor had been made by a Christchurch grower. This model, reduced to 39 inches axle width, was fitted with an underslung tank of 80 gallons capacity and a 5 horsepower Friend pump capable of a 12 gallons/minute nozzle output at up to 500 lb. pressure. The spray was delivered through an upright tail boom fitted with 8 nozzles.

Large machines of these types are virtually essential on holdings of any size though it is doubtful if either achieved the high level of performance possible with a stationary headland outfit and manually operated hoses and lances.

Virus Diseases.

The full story of the virus disease situation in New Zealand Raspberries is not yet known. However enough scraps of information are available to whet the interest of growers the world over in the results of more detailed work.

For one thing, apparently none of the American or European aphid vectors (carriers) of raspberry viruses occurs in New Zealand. Although certain stocks and varieties of raspberries in the Dominion have been found to be affected with a mild virus disease it seems likely that these stocks have been propagated from infected canes originally imported from overseas.

Under favourable growing conditions the health and vigour of canes was outstanding in all the areas visited by the writer during the past season. There were no indications anywhere of that degeneration of stocks due to virus disease which has caused such havoc in our own raspberry industry.

Mr. Giles Tuker brought home similar impressions from his visit in 1944-45, and these resulted in the Nelson Raspberry Marketing Committee kindly sending over a batch of Lloyd George canes to East Malling. The announcement in the press a short while ago that this stock has proved to be virus-free invited speculation on the virus status of other raspberry stocks and varieties in New Zealand.

In the absence of raspberry aphides New Zealand growers are at least in the fortunate position of being able to maintain and propagate virus-free stocks of cane with the minimum of trouble and in this we may find a permanent solution to some of our home raspberry problems. There should now be little difficulty in being able to supply Dominion growers with virus free stocks of the prominent British

varieties and in the future perhaps we may look forward to the prospect of New Zealand becoming a source of supply of healthy stock for growers overseas. The possibility is indeed tantalizing and its realization depends on the appreciation by Dominion growers of the ready market overseas awaiting the development of a supply of virus free stocks. For the present even if precise information about the health of stocks in circulation were available there would be no immediate prospect of supplies of cane from New Zealand. The proportion of plantations too old to yield planting cane is high and the planting systems in vogue do not, in general, lend themselves to cane production.

The New Zealand Department of Agriculture is fully alive to the situation and has already instituted a very practical programme of varietal selection and propagation work at the Dominion Horticultural Station, Levin. In co-operation with the Plant Diseases and Horticulture Divisions a representative set of samples from the material there is to be tested for virus content at Dundee this season and the outcome of these joint experiments should be of great mutual interest.

Summary.

A popular account is given of general impressions of raspberry culture and its associated problems, received during a three months tour of the Dominion of New Zealand.

CERTIFICATION SCHEMES FOR FRUIT PLANTS

By B. G. LEVY

Introduction.

There are now five separate schemes organized and conducted by the Ministry of Agriculture for the certification of nursery material of fruit trees, bushes and plants. The object of these schemes is to ensure that the present large demand for nursery material is satisfied, as far as possible, only by plants that are true to name, healthy and vigorous. Two of the schemes are compulsory and hence to some extent tend to limit the amount of material available for sale, but this is unavoidable if the wholesale spread and accumulation of disease is to be prevented ; especially important in this respect are the virus diseases, which spread with such rapidity after the 1914-18 war, when many worthless stocks were propagated in response to the large demand.

The conditions and details vary somewhat for each of these schemes and since they are not all widely known amongst growers, each scheme will be briefly described in turn, for the benefit of those who are not familiar with them.

Under the " Sale of Strawberry Plants and Black Currant Bushes Order " which came into force in 1946, it is illegal to sell any strawberry runners or blackcurrant cuttings or bushes unless they have been certified by the Ministry of Agriculture. Thus for the sale of nursery material of these two fruits, certification is compulsory. Where, however, the material is being used for planting on the propagator's own land and no sale is involved, certification is not essential. Certification remains voluntary for raspberries, fruit tree rootstocks, and Special Stock strawberries.

Applications for certification must be made to the Ministry of Agriculture before an advertised date in the spring and then inspection will be carried out by the staff of the N.A.A.S. at the appropriate time during the period June to September. The certificates are issued by the Ministry of Agriculture from whom can also be obtained a list of the growers who have qualified.

The Blackcurrant Certificate.

Although this scheme is compulsory, the conditions laid down for qualification are easily observed, comprising comparatively few restrictions.

One of the most important points is that all bushes should be true to name, without admixtures. All varieties of blackcurrant are eligible, including the various special strains and selections. It is, however, not always possible to distinguish in the field between closely related varieties or strains. Since most of them can be classified under one of four main groups, the certificate specifies the group to which each belongs. The name which the grower has adopted is also given on the certificate, in brackets after the name of the group. Thus Seabrook's Black would be given as : French Black (Seabrook's Black).

The four main groups are : French Black, Baldwin, Boskoop and Goliath.

There is, for the purpose of this scheme, a fifth group of " unclassified " varieties for those that do not exactly fit into any of the above four groups. The majority of the varieties included as " unclassified " are those varieties that have been raised from crosses between the groups, such as Davison's Eight, Wellington XXX and Westwick Choice.

Of equal importance with trueness to name is the question of health. It is essential for the plants to be free from obvious "Big Bud", caused by the Blackcurrant Gall Mite, and symptoms of the related virus disease Reversion, and to be at least fifty yards from any other reverted bushes or any plantation that contains more than 5 per cent. of reverted bushes. The general health of the plantation must also be satisfactory.

To facilitate inspection, the original cuttings should be planted far enough apart so that they do not grow into one another. The minimum distances recommended are 6 inches by 30 inches. Moreover, when more than one variety is grown in the same plantation, each must be separated and clearly labelled in the field, so that it can be readily referred to and lifted without mixing.

It is generally accepted that the symptoms of Reversion cannot be detected with any certainty on maiden bushes (that is on bushes formed from cuttings taken the previous winter) ; for this reason plants are not eligible for certification until they are in their second year. If, however, growers wish to sell maidens or cuttings, this is allowed by the Order, provided that the parent bushes were themselves certified in the year in which the cuttings were taken. Thus the material that can be submitted for inspection may consist either of two-year-old bushes in the nursery row, or bushes in the fruiting plantations that are to be used as parents for cutting material. It is recommended that cuttings should always be taken from such certified parents, whether they are to be sold as two-year-olds or maidens,

The Strawberry "A" Certificate.

This, also known as the "ordinary" certificate, is comparable to the blackcurrant certificate in that it is compulsory, covers a large range of varieties, and is governed by no stringent regulations as to the manner of cultivation of the parent plants. Both parents and runners are inspected in September and the certificate relates to all the runners produced from the parents in the year of inspection.

Twelve of the varieties in general use are named as being eligible for the certificate; in addition, certain other varieties "of which the characteristics have been recorded" will be accepted, provided that enquiries relating to them are addressed to the Ministry before the application form is submitted. Where the land is liable to Red Core, only those varieties will be accepted that are known to be resistant, e.g. Climax, Cambridge Early and Perle de Prague.

The inspectors judge a plantation mainly on trueness to name and freedom from virus diseases. There are in the strawberry three or four common types of virus diseases, all of which are passed on to the runners from an infected parent. No plantations will be certified where more than a small proportion of the plants show clear virus symptoms. It often happens that detection of virus symptoms is prevented by bad attacks of other pests or diseases, such as Tarsonemid Mite or Mildew, and in such cases certification is withheld even though there may not be any virus actually present. Similarly excessive weed growth must be avoided.

Most of the stocks of strawberries in cultivation to-day are by no means entirely free from some virus or other; in fact, completely virus-free plants have been found in only a few varieties. Furthermore, even in the case of a virus-sensitive variety such as Royal Sovereign, it is only when more than one virus type is present in a plant that it shows obvious symptoms; while plants of the virus-tolerant varieties, such as Huxley and Mme. Lefebvre, do not usually show marked symptoms unless infected with more than two viruses.

These facts explain why an inspector may pass plants that are infected by one virus only, since such plants may not be showing any obvious symptom. Thus the "A" certificate cannot be considered as a guarantee of complete freedom from virus infection. It is, however, an indication that the plants are above a certain minimum standard of health and that the cases of severe infection have been eliminated.

In order to reduce the likelihood of the spread of virus infection a few stipulations are made as to the manner of cultivation. For instance, adjoining beds of different varieties must be separated by at least one yard; each bed must be at least twenty yards from any other that is obviously affected with pests or diseases; beds of Sovereign and Paxton should be at least twenty yards from any other variety. But no restriction is made as to the age of the parent, nor as to whether they are used for fruiting or purely for propagation.

The inspections are carried out usually in September because the symptoms of "Yellow-Edge" disease show up most clearly then. This late certification has the disadvantage that the certified runners are not available for August planting. The advantage of August as compared with autumn planting is that larger plants are obtained in the following summer, from which a useful crop may be picked. It is not, however, generally worthwhile to jeopardize the health of the plantation for the sake of this first-year crop. If the plants are de-blossomed in their first year and cropped for the first time in their second year (in accordance with the latest recommendations), then autumn or even spring planting proves perfectly satisfactory.

As the regulations now stand, those who wish to plant in August, for first year fruiting or for cloche cultivation, must use their own runners (so that no sale is involved) and rely on their own roguing and inspection for maintaining the health of the plantation; or they must buy from a grower who has been specially licensed to sell plants for this early planting.

The Strawberry "Special Stock" Certificate.

While the ordinary "A" certificate should go some way to preventing the increase of serious diseases, the standards are not high enough to ensure maximum health and productivity of strawberry plants. Therefore the Special Stock certificate, requiring much higher standards of health and more strictly controlled conditions, was introduced in 1945. This certificate is voluntary, and the conditions are such that only those growers who can make runner raising a specialized job are likely to be able to fulfil them.

Full details of these conditions can be obtained from the Ministry of Agriculture together with advice on how to meet them. They are intended to ensure that only good pedigree stocks are propagated under conditions where the chances of fresh infection with virus disease are reduced to a minimum. The more important of these conditions are summarized as follows:

1. The stock must consist of runners that have themselves received the S.S. Certificate and are from one of the East Malling strains that have been tested for high yields and satisfactory virus status. At present* those permitted are :

Royal Sovereign	M.40 strain.
Huxley Giant	M.44 ,,
Oberschlesien	M.42 ,,
Perle de Prague	M.45 ,,

M. 40 is virus-sensitive and completely free from infection. The other three are virus-tolerant and are all infected with the mild crinkle virus. These strains must not be considered as virus-resistant, but they have been selected for the greatest possible freedom from virus and should remain in this state at least during their life in the runner bed.

2. The runners must be raised in isolation, that is normally one mile from any commercial fruiting plantation of strawberries. Sensitive varieties must also be one mile from any tolerant sorts, whether in fruiting or runner beds. The reason for this regulation is that the virus is spread from plantation to plantation by winged forms of Strawberry Aphid. It is not known how far or how fast these aphides can fly, but it is considered that they are unlikely to travel the distance of a mile in less than twenty-four hours. As it happens that one of the important viruses does not persist in the aphid for more than twenty-four hours, this distance of one mile should ensure immunity at least from this virus.

3. The plants must be cultivated in the " isolated block " system, for ease and certainty of roguing.

4. The plants must be de-blossomed so that no fruit is set. This, besides increasing the yield of runners, also ensures that no seedlings will arise in the beds and contaminate the strain.

5. Roguing (which consists of the inspection and removal of diseased plants) must be carried out by the grower periodically and at least once in the period May-June (when Crinkle symptoms are most obvious) and again in the period September-October (for Yellow-Edge).

6. The Strawberry Aphid should be kept under control. Nicotine spraying is not satisfactory for this purpose and nicotine fumigation is the method recommended. This can be carried out either by contract with a firm or by the grower himself using one of the small machines now on the market.

7. At the time of inspection the plants must be 100 per cent. true to type ; this means that there must be no seedling strawberry plants growing amongst the runners, nor admixtures of other varieties. There must also be less than 0·2 per cent. of plants that are " unsatisfactory " from the point of view of virus infection or on general grounds. An appreciable amount of any other serious disease or pest will disqualify the bed, particularly if the symptoms are such as to prevent the detection of virus.

8. The life of the runner bed must be limited to one year. A new plantation, planted on new ground with runners that have been dipped in nicotine, stands a better chance of remaining healthy than a bed allowed to go on for a second year.

For this certificate the Ministry inspections are carried out twice, once in each of the periods May-June and September-October. It should be understood that the inspectors cannot do the roguing for the grower who must carry out his own inspections for this purpose. A bulletin on the raising of runners in Special Stock nurseries appeared in the *East Malling Research Station Annual Report for 1943*, pp. 87-93, and the method is also fully described in Bulletin No. 95 on Strawberries (price 2s. from H.M. Stationery Office).

A fruiting plantation that has been planted with Special Stock Certificate runners or even with runners " once grown " from Special Stock plants, should give a much higher standard of performance and a longer life than one stocked from the general run of ordinary certificated plants.

The Raspberry Certificate.

At present there is only one grade of certificate for raspberries, which, like the Special Stock certificate, is voluntary and limited to certain varieties only. In this case, however, there are not so many conditions governing the method of cultivation. Fruiting plantations can be certified at present but it is recommended that the plants should be grown in special nurseries or "spawn beds" isolated at least to some extent from other varieties or from fruiting plantations.

A spawn bed consists of a plantation in which the canes are planted two feet apart in the rows and six feet between the rows. Only first-year cane is allowed to remain in the beds so that no fruiting is possible. At the end of each year the first year canes are dug out and those that are sufficiently rooted are used as " spawn " (i.e. for propagation) ; the roots that have not been removed from the beds with the spawn will produce fresh canes in the following years. A full description of this method appeared in the *East Malling Research Station Annual Report for 1947*, pp. 109-13.

* In 1949, Climax M.46 will be included.

The raspberry viruses appear to spread from plantation to plantation less readily or more slowly than the strawberry viruses. For this reason a distance of fifty feet is regarded as sufficient isolation for virus-sensitive varieties, though further distance is necessary for virus-tolerants.

The eligible varieties are at present as follows :

Norfolk Giant—sensitive but highly resistant to infection.
St. Walfried—sensitive, not so highly resistant to infection.
Malling Promise—tolerant and fairly resistant to infection.
Newburgh—highly tolerant.

The varieties included in this scheme are only those that can be obtained reasonably free from virus and for one reason or another (e.g. resistance to infection, high sensitivity, etc.) can be kept so, at least in nursery spawn beds. Newburgh is an exception to this, for it is very tolerant and generally infected, but it has not, as yet, shown any obvious degeneration effects as a result of this infection.

Lloyd George is not included in this list as even the best strains at present available are known to be completely infected with at least one virus ; moreover, being a tolerant, it is impossible to prevent the spread of infection by roguing alone. When the new virus-free strain from New Zealand, which is being propagated in Scotland and elsewhere, becomes generally available it may also be included in a certificate scheme.

There are not, as yet, many growers taking part in this certification scheme ; in 1947, its fourth season, only some fifteen acres of Norfolk Giant and a third of an acre of St. Walfried were certified.

Fruit Tree Rootstocks.

The scheme for rootstocks has only been in action for two seasons, but it has already attained some popularity and about forty acres of stool and layer beds were certified in 1947.

In the past it has not been possible to buy worked fruit trees with any guarantee that the rootstocks were of the same uniform type or of the particular type required. Many plantations to-day witness the fact that they have been planted up with mixed stocks ; others, planted with bush trees on so-called dwarfing stocks, at distances suitable for such, have developed vigorous trees, requiring much thinning or " cutting up ".

Nowadays, as a result of stock certification, the buyer can specify and be reasonably sure of obtaining trees worked on the stocks he wants. The nurseryman with reliable stocks also gains by having them certified and recognized as such.

In this certificate, most attention is paid to the correct naming of the stocks. Seven of the most popular Malling apple stocks and six of the vegetative plum stocks are eligible ; any of these submitted for inspection must be completely true to name and unmixed. If the stocks are not easily identifiable owing to lack of vigour or are substantially affected with pests, especially Woolly Aphid, or diseases such as Scab or Mildew, they will not be certified.

The inspections are usually made in the summer. In this scheme, if the nursery material is not passed by the inspectors in the first instance owing to the stocks being mixed, the grower is allowed after roguing to apply for re-inspection on payment of a further fee.

The material will be inspected either in the stool or layer beds themselves or when lined out in the nursery rows, ready for budding in the same summer or for grafting the following spring. As with other certificates, care should be taken that all lots are clearly labelled and sufficiently separated from neighbouring lots of a different kind. There is the added stipulation that when the worked trees are sold under the certificate they should be labelled, showing the name of the stock and the number and year of the certificate. Once a tree has been certified it can, of course, be sold at any age, whether maiden or older.

Summary.

A brief description of the certification schemes for fruit plants, drawing attention to the conditions and advantages of each, for the benefit of growers who are not already familiar with them.

A NOTE ON THE HORMONE TREATMENT OF CUTTINGS

By E. S. J. HATCHER and R. J. GARNER

This note has been written in response to recent enquiries about the use of synthetic hormones as root stimulants.

Vegetative propagation methods underlie the practice of rootstock selection and have been studied at East Malling Research Station throughout its history. Many fruit-tree rootstocks are difficult to propagate, so that, following the introduction in 1935 of synthetic growth substances, their possible use in relation to the fruit-tree was extensively investigated.

Technical Communication No. 12 of the Imperial Bureau of Horticulture and Plantation Crops (" Plant hormones and their practical importance in horticulture " by H. L. Pearse, 1939) presented the widespread evidence of the root-promoting activity of the new hormonal substances. With regard to rootstocks, however, although hormones accelerated the rooting of many varieties as softwood cuttings, they had little effect with these same varieties as hardwood cuttings.

Technical Communication No. 14 of the Imperial Bureau of Horticulture and Plantation Crops (" Propagation by cuttings and layers. Recent work and its application with special reference to pome and stone fruits ", by R. J. Garner, 1944), surveyed the many problems of rootstock propagation and also initiated a new phase in East Malling researches. The hormone factor may, in fact, be regarded as one of several interacting to determine the behaviour of the cutting. Many of the experiments will be in progress for several years, and the experimental background of this research is given elsewhere in this Annual Report ; in the meantime here is a short statement for horticulturists, nurserymen and growers wishing for information about hormone treatments.

Enquiries fall into three categories :

1. Those relating primarily to the techniques of hormone treatment.
2. Those relating to the use of hormones with rootstock varieties.
3. Those relating to the use of hormones with other plants not studied in detail at East Malling.

1. The Technique of Hormone Treatment.

(*a*) What hormone substance should be used ?

A very large number of new chemicals have been made by the chemist but the standard hormones for rooting cuttings continue to be α-naphthalene-acetic acid and β-indolyl-butyric acid, two of the first to be introduced.

One of the merits of α-naphthalene-acetic acid is its relative cheapness, being in good commercial supply for use in controlling pre-harvest fruit drop. Its root-promoting powers are generally recognized though it has one drawback, in that sometimes the roots produced are large, fleshy and brittle, unsuited to transplanting. On the other hand, β-indolyl-butyric acid, while somewhat expensive, stimulates the production of prolific, fibrous root systems, much more normal in appearance, and more resistant to transplanting checks. This latter hormone is the one most used in the experiments at East Malling.

(*b*) In what form should the hormone be applied ?

The usual methods, fully described in T.C.14 (referred to above) are the solution method and the dust method. In the solution method, cuttings are stood for approximately twenty hours with their bases in a dilute water-solution of the hormone, the concentration varying according to the plant from five to fifty parts per million. In the dust method, the moistened base of the cutting is treated with the hormone mixed with talc powder, a usual proportion being one per thousand by weight. Comparing the two methods, the latter is perhaps less trouble, but the former is by far the safer and more reliable.

At East Malling these methods have been superseded by the " concentrated dip " method, with results comparing favourably with those from the older techniques, and with the advantage of being both instantaneous and reliable, thereby combining their respective virtues. The " dip " consists of a solution of the hormone in 50 per cent. alcohol. To prepare, dissolve 1 gm. of the hormone in 500 c.c. of alcohol (methylated spirits) and dilute with an equal volume of water (500 c.c. is approximately one pint). This provides a stock solution which will keep its activity indefinitely. To use, momentarily dip the base of the cutting in the solution to a depth of $\frac{1}{2}$ to $1\frac{1}{2}$ inches, varied according to its overall size. The alcohol evaporates almost immediately when the cutting is taken out of the solution, leaving a deposit of the hormone. The cutting is then ready for immediate planting. Often it is advisable

to try more than one concentration of dip, especially with a variety not previously used, and the stock solution can for such a purpose be diluted to $\frac{1}{2}$ and $\frac{1}{4}$ strengths with a solution of alcohol and water in equal proportions. Our own results tend to favour a " dip " of $\frac{1}{2}$ stock strength for fruit-tree cuttings.

2. The Use of Hormones with Rootstock Varieties.

The indiscriminate use of hormones is unlikely to make hardwood cuttings a practical means of propagating rootstocks not normally propagated in this way. Our experiments at East Malling show that the cultural history of the parent plants is often a deciding factor, and it is impossible to assess how useful hormone treatment is likely to be without taking this into account. If the condition of the cuttings is suitable, then good results may be obtained, even with varieties normally difficult to root. At present our knowledge of the right conditions is incomplete and this hardwood cutting technique cannot yet be recommended on a commercial scale for the majority of rootstocks.

To a horticulturist or nurseryman who wishes to experiment, we would recommend the " dip " treatment already described, and emphasize that it is not the hormone that is on trial but the hardwood cutting method itself. It is therefore most necessary to keep as full notes as possible about the source of the cuttings, age of parent plants, how grown (layer, tree, hedge etc.), dates of taking and planting, soil and weather conditions, and finally an accurate count of the number successfully rooted and the number that fail. We encourage experiments of this nature because it is necessary to extend to other varieties, principles evolved with a few, and such experiments help to reduce the time that must elapse between the first experiment at a research station and the commercial utilization of its results. We, therefore, invite anyone who intends to experiment on these lines, to let us know the sources of the cuttings he wishes to take so that, where possible, we may make detailed suggestions.

3. The Use of Hormones with Plants not Studied at East Malling.

The capacity of different kinds of plants to root as cuttings varies tremendously and there is likely to be an equally wide variation in response to hormones. It is, however, often worth trying the " dip " treatment, especially if brief systematic records are kept so that good results can be repeated another time. Such records will also contribute to the general pool of experimental data from which a thorough understanding of the problem may ultimately emerge.

Summary.

The use of synthetic hormones as root stimulants is discussed for the guidance of those who wish to experiment with them in cutting propagation.

THE PROBLEM OF THE FRUIT TREE RED SPIDER

By H. B. S. MONTGOMERY*

Introduction.

Although known as the Fruit Tree Red Spider this pest is not a spider at all, but a mite known to entomologists as *Metatetranychus ulmi* (Koch) Oudemans, 1931. This name replaces two others by which it was known in the past, i.e. *Oligonychus ulmi* (Koch) 1920 and *Paratetranychus pilosus* (Canestrini and Fanzago) 1877. It has long been known in England and was recorded by Theobald in 1909 as a beneficial mite. It then fed on the lichenous growths that were usual on all fruit trees. Theobald did, however, observe one case where this mite caused bronzing of plum foliage and he may well have foreseen the possibility of it becoming a pest. In 1925 Dr. Massee first drew attention to the changed habits of Red Spider. The use of tar oil washes, recently introduced from the Continent, had resulted in trees free from lichen and the Red Spiders, deprived of part of their usual food, began to feed on the foliage of the fruit trees. At the same time the tar oil washes probably destroyed insects that normally preyed on the spiders, leaving the spiders free to multiply unchecked. About 1928 work on Red Spider was begun at East Malling as time permitted, but there were then many other more pressing problems to occupy the entomologist and it was not until 1943 that the problem was officially recognized as of sufficient importance for a special attack on it to be made. This change of outlook was largely due to the Associated Fruitgrowers of Essex Ltd., and the Pettar Society of Winter Wash Manufacturers who went to the Agricultural Research Council and urged the importance of the problem. As a result the Red Spider Investigations in Essex were begun ; Dr. Massee was asked to take charge and a special team of workers was appointed. So that the work might be done where the problem was most serious a special field laboratory was set up at Great Braxted in Essex.

The Fruit Tree Red Spider is an animal of minute size and thus its study presents great difficulty. Its habits can only be observed with the aid of a magnifying glass and these habits must be accurately known before spray treatments can be correctly timed. When the work began there were no reliable methods for recording the results of spraying trials in the field, nor indeed for testing spray materials against the pest in the laboratory. These problems were worked on and solved during the first years of the investigation at the same time as preliminary field spraying trials were begun.

Winter Spray Control.

In the first year, 1943, four field trials were undertaken, trying out petroleum oil emulsion and D.N.C. sprays (6 per cent. actual oil) at different times during the months of January, February and March. The results of these trials shed little light on the practical problem of the control of Red Spider although indirectly they proved most valuable. In the trial at Writtle there was no Red Spider at all by the end of June, even on unsprayed trees ; predaceous insects appeared to be responsible and this line of research was obviously worth detailed study. At Great Braxted the mite population was equally high on all plots by the summer, and it seemed that this was due to migration from one plot to another. Here was another promising line of study, and migration was put into the programme for serious study. During the season methods of recording results were being developed. It was not possible to assess results in the field by estimating infestations, and proper counts on sample leaves took too long to be practical. The statisticians required results from many samples in different parts of each trial and to get this done quickly a mechanical recording device was needed. This was eventually found in the imprint technique. This method had been tried for a pest on citrus and discarded as unsuitable, but with Red Spider it proved excellent. Leaves are laid between sheets of paper and then passed between the rubber rollers of a mangle. The mites and their eggs are squashed and leave permanent impressions on the paper, which can be stored away for counting when time permits. In 1943 rubber-roller mangles were unobtainable through the ordinary suppliers, and the first one used in these experiments was hired from a housewife in East Malling village. Since then a special mangle has been evolved with rollers of just the right hardness, and this apparatus, together with specially selected paper, makes possible accurate estimations of results with differences as small as 5 per cent. Since this first year, seven winter wash trials have been done and the results show that the later in the dormant

* Based on the talks given at the Members' Day on 12th December, 1947, by Dr. Massee, Miss Collyer, Miss Groves, Mr. Austin and Dr. Eaton.

period the wash is applied the more effective it is, thus February sprays gave better results than earlier ones, and March sprays were even better. This is a most important result and the insect physiologists are trying to find out the reason for it. A trial of petroleum oils in late March showed that stock emulsion and miscible oil type washes, used at 3 per cent. and 5 per cent. actual oil, all gave good results with scarcely anything to choose between them, except that, with the weaker sprays, spray damage was largely eliminated.

The conditions for good winter control of Red Spider were thus established, but unfortunately winter control is not the end of the problem. In fact, where the population of mites has been reduced to a minimum by such winter spraying, the multiplication of the pest during the spring and early summer is so rapid that by July and August there are more mites on the trees than if no winter spraying had been done. Something more is needed, and a knowledge of the life cycle supplies the missing clue.

Life Cycle.

The familiar minute red globular winter eggs are very resistant and are laid all over the tree. They hatch out from the end of April until June ; some idea of how small these newly hatched mites are can be formed from the fact that 125 of them can fit head to tail along one inch. They develop in a series of stages, shedding a coat at the end of each stage, and at the end of the third stage the females become mature and each can lay some thirty eggs over a period of a couple of weeks. The eggs hatch out in one or two weeks according to the time of year, and there can be up to five generations in a year. Thus one egg missed in the winter spraying could build up to 160,000 mites by the end of the summer and they would lay some 4,000,000 eggs to overwinter and start trouble the next season.

Summer Spray Treatment.

It is necessary, therefore, to have a summer spray to deal with the progeny of the small number of winter eggs that survive the winter treatment. Since all the mites do not hatch out of the winter eggs at the same time in the spring, the summer generations are not clear cut but overlap and it is possible, at all times after the first hatched female has become mature, to find immature mites, adult mites and eggs together on the leaves. In spite of this the problem of supplementing the winter spray by a summer spray would be simple if a spray material could be found that was effective against all stages of the mite, and was also harmless to the tree. Unfortunately the only materials we know of at present that are capable of killing all stages are liable to damage the trees and the existing safe materials are really effective only against the mites. Research is actively in progress to find the ideal material and in the meantime the timing of the summer spray treatment is of major importance. There is a short while after the last winter egg has hatched, but before the first hatched female has matured and laid eggs, when there are only mites on the tree. This is the time to spray with some material that kills the mites. It is clear that this time must be accurately determined or the treatment will go on before the last winter eggs have hatched and they will survive to start a new infestation, or after the first females have begun to lay eggs, leaving their eggs to carry on the trouble after their destruction. As a rule the time for this spray appears to be about the first week in June, but it can be accurately determined only by close observations. These observations are made as part of the routine work of the Red Spider investigations and it is proposed to pass the information on to the provincial advisory centres for the assistance of growers. It is true that the routine lime-sulphur sprays applied for apple scab do kill large numbers of mites, but it has been found that they have no effect on the mites in the resting stage preparatory to shedding a coat. On the whole, the most effective material at present known is Derris with a good rotenone content (i.e. 2 per cent. rotenone), and 2 lb. of this Derris should be added to 100 gallons of wash. A second spray can be applied ten days or a fortnight after the first to catch any mites that may hatch from eggs present when the first spray was applied.

Predators.

Red Spiders have many insect enemies that are constantly preying on eggs and mites in all stages—in fact no less than thirty distinct insects feed on them. Observations in autumn, 1947, showed a very high egg population following the hot dry summer, but by October no less than 64 per cent. of these had been destroyed by such predators. The use of DDT during the summer has always led to an increase in spider by killing predators, the increase being noticeable as soon as three weeks after the spraying. When used before the blossom period, however, DDT does not have this bad effect on the predators. The usual winter washes affect many of the predators but fortunately one very useful one, *Blepharodopterus angulatus*, is not affected. This green capsid bug resembles the apple capsid but has a narrower body. As it is identified by its black knees, it has been named the *Black-kneed predaceous capsid*. Each capsid can consume about 3,600 active mites in its lifetime, and in many orchards this

capsid is plentiful and capable of doing good work. Unfortunately routine winter pruning removes many shoots bearing the eggs of this capsid and the eggs in such shoots do not hatch. It is tentatively suggested that half-a-dozen trees or so might be left unpruned until the third week of May, when the eggs are about to hatch. They could then be pruned and the prunings carried to parts of the orchard where Red Spider is present. It is not thought, however, that predators, such as this capsid, will ever suffice alone to keep Red Spider in check, for not only do winter washes affect some of them but some feed on other insects, aphides, etc., and even on each other, and they may migrate to other orchards when the Red Spider population drops, leaving summer eggs of Spider to carry on after they have gone.

Summarized Recommendations.

It is not yet possible to give final recommendations for the control of the Fruit Tree Red Spider. The investigations are still going on and much more has to be discovered, but certain interim advice can be given.

1. Apply a winter wash containing petroleum oil emulsion (3 per cent. actual oil) during the latter part of February or in March. Thorough spraying is essential, for every egg missed may mean 4,000,000 eggs next winter.

2. Apply Derris spray (2 lb. of Derris powder of 2 per cent. rotenone per 100 gallons) during first week of June, when all the winter eggs have hatched and before any summer eggs have been laid. Repeat this spray about two or three weeks later as an extra precaution. The post-blossom lime-sulphur sprays against scab also contribute to good control of spider.

Summary.

A popular account of recent research on the Fruit Tree Red Spider with suggestions for its control in the light of present knowledge.

THE HOP RED SPIDER (*TETRANYCHUS URTICAE* KOCH)

By A. M. MASSEE

The Hop Red Spider has been very prevalent during recent years and in many gardens and hop yards the crop has been materially reduced by this pest. In most seasons the variety Fuggle is more susceptible to attack, but in recent years Goldings and some of the newer varieties suffered so some extent also. The severe infestations of last season were doubtless, in part, due to the drought conditions prevailing during the summer months.

Recognition and Notes on Life Cycle.

The Hop Red Spider is minute and very difficult to detect on the foliage until a bad infestation has been built up. The name " Red Spider " is somewhat misleading since only the overwintering females are red, while the summer forms, which cause the damage, are pale yellowish green with darker markings.

The only stage to overwinter is the brick red female which matures in September and hibernates in the cracks of the poles, in dried leaves, under stones or in dry soil situations within the garden. The Red Spiders find their way back to the hills in the spring as soon as the bines begin to grow out from the hills—usually during the latter part of April or early in May, depending on the season. The Red Spiders begin to feed upon the young leaves when the bines are less than one foot high and soon lay the minute, globular, transparent eggs on the under sides of the leaves. The best time to combat this pest is when all the mites have returned to the hills from their winter quarters, but before they lay their summer eggs on the leaves and before the " webbing " of the foliage begins.

Control Measures.

During recent years the recommendations for the control of the Hop Red Spider have been modified considerably. For example, the older practice of spraying the hops in August with liver of sulphur has been completely superseded by the early application of a lime-sulphur or Derris preparation.

The application of a one per cent. lime-suphur spray or a Derris spray (2 lb. of derris powder, containing 2 per cent. rotenone, per 100 gallons) at the end of May or early June is strongly recommended. In practice the spray should be applied when the lower leaves of the bines have been stripped but before they reach the breast (or tying-in) wire. One application may prove sufficient, but in seasons when the Red Spiders come out of hibernation over a long period, a second application should be applied about a week or ten days later.

When the Hop Damson Aphid or Hop Fly is present nicotine may be added to the lime-sulphur or Derris spray at the rate of four ounces to the hundred gallons. A wetter may also be necessary where the water is hard.

The spray can be applied by means of a power sprayer or by a " Hop Washer" machine. A medium spray should be used, care being taken to wet the under surface of the leaves very thoroughly.

Investigations carried out at East Malling and experience gained in the field showed that the above sprays will not scorch the leaves or check the growth provided the lime-sulphur is not applied during the hottest part of a sunny day in a " housed-in " hop garden. On some heavy soils a few growers believe that the lime-sulphur applications may check the growth and render the leaves brittle and harsh ; in such cases the Derris preparation is preferable. If for any reason the application of the lime-sulphur spray is delayed until July, care must be taken to ensure it does not coincide with any form of copper spray, which is used as a routine against Downy Mildew. A period of ten days should elapse between the application of the two sprays.

As stated already, the object of the early spray is to destroy the adult female mites before they begin to lay their eggs on the leaves and before they start to spin their canopy of webbing on the under surface of the foliage. All hop gardens which suffered from a severe attack of Red Spider last season should receive the early lime-sulphur or Derris application as a matter of routine.

When a Red Spider attack is not detected until the latter part of July or in August, it is still safe to apply a one per cent. lime-sulphur spray or Derris preparation. It must be emphasized, however, that the presence of Red Spider eggs, which are not killed by the lime-sulphur or Derris preparation, and the protective canopy of fine silk, considerably reduce the effectiveness of the application. Also, if the bines have been materially checked or stunted by the infestation, then slight leaf injury may result on some varieties. The moral is, apply the early application.

Subsidiary Control Measures.

When a garden is so badly infested that the foliage turns brown and hops are unsuitable for picking, every effort should be made to burn the bines before the Red Spiders migrate from the leaves and seek their winter quarters during the latter part of September. When cutting the bines before burning, two or three feet of bine should be left attached to the hill to reduce the amount of bleeding which results from early cutting.

In addition, many hop growers follow the practice of broadcasting five cwt. per acre of crude commercial naphthalene directly after picking, in gardens where the Red Spider populations have been abnormal. This treatment is recommended since it is also partially effective against the Hop Strig Maggot, another important hop pest.

A control measure sometimes advocated, namely that of spraying the poles with a tar wash, petroleum or lime-sulphur spray is not to be recommended. While it is true that large numbers of Red Spiders hibernate in the cracks of the poles, in beetle holes and in crevices, it is not possible to direct the spray into such situations, thus the treatment is not a practical one.

In brief, the recommendations for the control of the Hop Red Spider are as follows :

Timing of Application.

The spray should be applied in May or early June when the lower leaves of the bines have been stripped but before they reach the breast (or tying-in) wire. A second application may be made ten days later, if required.

Formulae—per 100 gallons.

(1) Lime-sulphur, 1 gallon.
Wetter (according to maker's instructions), about 6 oz.
Nicotine (can be added if Hop Fly is present), 4 oz.

(2) Derris,* 2 lb.
Wetter, about 6 oz.

Summary.

The measures for the control of Hop Red Spider in the field are brought up to date in this article.

* It should be noted that derris preparations are very unstable and only preparations of the correct rotenone (2 per cent.) should be used. Derris preparations should be stored in well-made containers away from the light.

THE PROPAGATION OF HOPS BY LAYERING

By W. G. KEYWORTH

The need for new and more rapid methods of hop propagation has become increasingly apparent in recent years, largely because of the spread of such " set-borne " diseases as Verticillium Wilt, Nettlehead and Mosaic. The old method of propagating from strap cuttings, whereby on the average some five new plants are obtained from one hill, has two main disadvantages. The number of parent hills required is large, making adequate roguing for disease very difficult, and the annual rate of multiplication of stock is very low. Two main types of new method are available. One, the rooting of the surplus young shoots and laterals in frames, has been dealt with in previous reports by Mr. F. H. Beard and will not be considered here. These methods are of value to growers with the requisite nursery facilities and those who are interested should consult previous issues of the *Annual Report** for details. The other type of propagation, namely by *layering*, has also been studied in some detail and three methods will be described below. Layering can be done with equipment normally used by hop growers, and seems likely to prove of most general value. The layering process depends upon the fact, that although the aerial part of the bine dies at the end of the season, the part beneath the soil remains alive and can be used for propagation. In the normal production of "strap-cuts" only a few inches of bine are so buried giving only one cutting per bine. By layering on the other hand several feet of bine are buried and each node (joint) in this length becomes a potential cutting.

General Considerations.

There are several occasions on which layering may be advisable. A grower may have a completely disease-free garden and wish to raise stock especially from it over a short period ; a special isolated nursery may be established to produce high grade stock over a period of years ; or it may be desired to raise large quantities of stock rapidly from a small nucleus of cuttings or bedded sets (of, for instance, Wilt resistant varieties). Methods are now available for meeting all these requirements, but it must be emphasized that the techniques suggested are still open to improvement and a grower trying them out should, therefore, use such modifications as local conditions suggest.

The parent plant used in these methods must be selected with great care, for obviously when each parent stock gives a very high yield of cuttings a single diseased or rogue plant becomes correspondingly more dangerous. Growers are advised to use, if possible, only plants which are completely free from all the main set-borne diseases. It is also an advantage in the establishment of a new nursery for the stock to be clonal (i.e. initially raised from one plant). Such plants can at present be obtained in small quantities from the Research Station and some of its daughter nurseries.

The best soil for a new nursery is a deep well-drained loam, but very successful ones have been established on heavy ground. It would appear necessary to avoid only the extremes of clay or sand and badly drained soil. New nurseries for the production of special stock should preferably be as far away from commercial hops as possible and any wild hops in the hedgerows should be removed. Exposed sites are unlikely to prove satisfactory owing to battering by winds. Districts with very high rainfall may also be unsuitable owing to the increased risk of Downy Mildew in certain varieties. As potatoes may infect the soil with a mild form of Verticillium Wilt the site selected should preferably not have grown this crop during the previous three years.

In choosing the varieties to grow it must be borne in mind that the Goldings and Golding varieties are sensitive to Mosaic disease and should, therefore, not be planted with any other varieties, most of which may carry the virus.

Liberal manuring to ensure adequate humus, nitrogen, potash and phosphate is advisable both before planting and annually thereafter and the ground should be kept well cultivated during the summer and ploughed in the winter.

Spraying against Aphid attack and Downy Mildew will usually be necessary and also possibly dusting against Mould. The recommendations already published by Wye College on these control measures should be consulted for details. A two horse-power fruit washer with sufficient hose to stretch down narrow rows will be found most suitable for this purpose.

* *Reps. E. Malling Res. Sta. for 1945 and 1946.*

Layering Method No. 1.

This method has been in use at the Research Station and on some farms for many years and is the only one applicable to an established hop garden. It has already been fully described by Beard* and is briefly as follows.

The method can be used only where cultivation proceeds in one direction. Cropping of the plants continues normally, the usual six or eight bines being selected for this purpose and trained up the strings. Instead of removing all the remaining bines at pulling time, however, about six of equal length (some two feet long) are selected and laid on the soil along the row. They are then covered with soil except at the tips which are free to grow. This process is repeated as the bines lengthen until after some four or more earthings the bines have reached the next plant up the strings of which they are then trained. Each plant thus bears its cropping bines and up to six layer bines covered by a complete ridge of soil stretching to the next plant. These layer bines are dug at the end of the season.

Although relatively simple, this method, in practice, has two main disadvantages, namely, the layer bines are easily damaged by cultivators, etc. because they grow at ground level and have no supporting strings, and when they reach the next plant they have to compete with its already advanced bines. It has the one main advantage, however, that the layers produced are fairly " short jointed " as only young bine is buried.

The yield of cuttings is variable, depending on the care taken with the several earthings and the measures to ensure that the bine tips are not damaged and grow freely up the next plant. Under favourable conditions some fifty cuttings should be obtained from each mature plant.

Layering Method No. 2.

To overcome the disadvantages of Method No. 1 a new technique was devised which has proved satisfactory in trials for some three or four years and which is now recommended for use in a special layer nursery. This method, however, also has certain disadvantages which will be indicated later.

1. Setting Out the Layer Bed. Single bedded sets should be planted any time between mid-October and early April, at 7ft. 6 in. apart in rows seven to eight feet wide. The row width depends on the cultivators available and due allowance must be made for a ridge of soil eighteen inches wide which will be made along each row during the summer. 7 ft. 6 in. should be allowed in the row beyond the last hill, as layering space for that hill. The plants will remain permanently in these positions and must be provided with wirework not less than eleven feet high. The poles should be thirteen feet high, two inches in diameter at the top and spaced fifteen feet apart along the rows, i.e. midway between every other plant. The bottom eighteen inches of each pole should be dipped in hot tar for twenty-four hours. The poles are generally placed fifteen to eighteen inches in the ground and are braced by three or five strand galvanized wire running the whole length of the row at the required height (eleven to twelve feet). The wire is secured to guy stumps at each end of the row and stapled to each pole. Cross bracing wires every fifth pole will usually be necessary. Ample room should be allowed at the headlands (say five yards).

2. Stringing. Each plant is provided with four strings running from a screw peg in the ground close to the plant, to four hooks on the wire above. The screw peg is bent at right angles after screwing into the ground, to enable the pairs of strings to be separated at the base and facilitate training the young hop bines. The hooks are fastened to the wire after its erection, either by means of a special hooker or by clipping them on with pliers from a step ladder. Two hooks are placed $2\frac{1}{2}$ feet apart above each plant and two hooks six inches apart above the point between each plant. The strings are put up by fastening one end to the screw peg in the ground and then passing the string, by means of a short tube on the end of a pole, over the two hooks to the left of the point above the plant and back to the screw peg, there tying off. The process is repeated over the two hooks to the right of the plant, producing a " double V " appearance as shown in Fig 1.

3. Method of Layering. When the direction of layering has been determined, the forward pair of strings will carry the layer bines and the back pair of strings the " feeding " bines. These latter are so called because, being unlayered, the food substances they produce pass direct to the rootstock and thus enable it to grow.

Each mature plant should throw a large number of bines each spring, from buds on the rootstock. When most of these bines are about eighteen inches long, all except eight of medium size should be pulled out. These eight bines are trained in a clockwise direction, *one* up each of the back strings and *three* up each of the forward strings. On first year plants, one feeding bine and one or two layer bines are sufficient, and even in the second year it is unlikely that a full complement of bines can be trained on each plant.

* *Rep. E. Malling Res. Sta. for 1943* (1944), 112-4.

All the bines are allowed to grow until they are nine or ten feet high (about the end of June), new bines at the base having been pulled out. The layer strings are then unhooked from the top wire and the bines laid in a four inch deep V-shaped trench running the length of the row. The layer strings are cut near the screw peg or unhooked so that the bines can be laid flat. Some two feet of bine will overlap the next plant and when new strings are put up in the layer positions the ends of the bine are trained up them. Finally, the layered bines are covered with soil by ploughing up each side of the row.

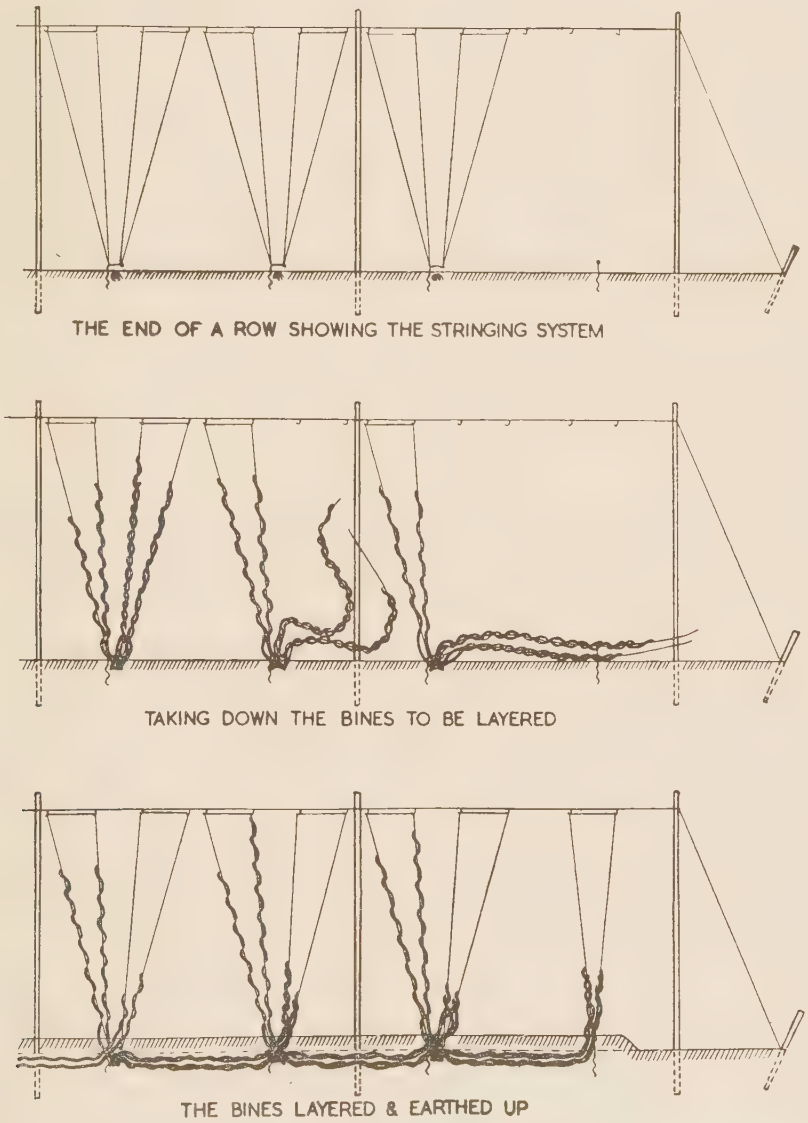

Fig. 1.
Diagram of layering method No. 2.

to form a continuous ridge eighteen inches wide and nine inches high over the layers and the base of each plant. The centre of the ridge must be carefully filled in to form a complete covering. At each plant position there will then be two feeding bines ten feet high and six layer bines about two feet high, which come from the neighbouring plant.

As will be seen, the first plant to be layered in each row should be the one at the end toward which the layers point. Its layers will occupy 7 ft. 6 in. of row and the ends are trained up strings put up especially for this purpose. The layering of the rest of the plants in the row then follows in succession.

It is most important that the tips of the layered bines should grow freely, for if the tip is buried the whole bine will die. After the layered bines have grown nine feet up their new strings, the leaves from the bottom four feet of all bines can be stripped off to facilitate spraying. The leaves must not be stripped off before layering, as buds on the portion to be buried may be damaged, resulting in blind or useless cuttings. The layered bines should grow vigorously to the top wire and produce a crop of hops. If wind damage is likely, the strings may be laced together by means of a string running along the row five feet above the ground.

4. Lifting the Layers. The bines die back by the end of October and can be cut off at ground level and burned. The layers should then be raised carefully by inserting forks under them from each side. The soil is removed from the base of each plant and the layered bines severed close to the parent, the bases of the feeding bines and any runners being trimmed off for use as cuttings. If the plant is young, care must be taken not to cut off the whole crown but after two years severe trimming is advisable.

5. Comparison with Method No. 1. As, by method No. 2, the bines are not layered until they have grown for nine or ten feet, they are in a more mature condition than those layered by method No. 1. Although this does not appear to affect their ability to thicken and produce layers, it does, however, mean that the internodes have lengthened considerably and thus fewer cuttings are likely to be produced per unit of bine length. An experiment in which this point of difference was studied showed, however, that it resulted in only a small reduction in the total number of cuttings obtained per plant. In general a yield of some fifty cuttings per mature plant may be expected.

The method has the following advantages. As the bines are grown up strings until layered they are less liable to damage, and as they are then put down in one operation, it is possible to carry out the single earthing with a plough. Also the tips climb up empty strings and can thus grow freely, resulting in a greater transference of food material to the layer.

Layering Method No. 3.

In certain circumstances, e.g. when it is desired to multiply rapidly a small but valuable stock, the previous methods, using permanent mature plants, are unsuitable. In the rapid production of special stocks it is desirable to be able to repropagate *immediately* from any cuttings produced and thus avoid the delay involved in raising mature plants. With this in mind the following method of producing layers from cuttings was devised and appears of value in certain cases.

1. Setting Out the Layer Bed. The cuttings are planted in the same fashion as that described (below) for planting a nursery bed for the production of bedded sets, but are spaced one foot apart in rows set some five feet apart or less depending on the width of the small cultivators used.

Poles six feet high are inserted with about one foot in the ground at intervals of fourteen feet along the rows and connected by a three-strand galvanized straining wire running the whole length of the row near the tops of the poles and firmly guyed at each end. A flexible layering wire (e.g. telephone cable) is then fastened to a nail in the first pole at a height of eighteen inches from the ground and stretched over another nail in that pole just below the straining wire and three feet above the lower nail; thence over a top nail in each pole to the end of the row where it is fastened to the top nail in the end pole. Each cutting is provided with a vertical string attached to this layering wire and fastened at ground level to a bottom wire. Pairs of nails $\frac{1}{2}$ inch apart are put into each pole eighteen inches from the ground with a single nail at this height in the end pole.

2. Layering. All the bines in the row are layered simultaneously, when most have reached a height of about 4 to $4\frac{1}{2}$ feet, as follows. The layer wire is unhooked from the top nails and stretched tight along the row at the height of the lower nails, being slipped between each pair of nails on each pole. The slack at the far end of the row is taken up by putting the wire under the lower nail on the last pole whence it stretches up to the top nail. The effect of this is to lay the strings and bines along the ground for three feet, the remaining eighteen inches of string and bine rising vertically to the layer wire. The layered bines are then covered by a ridge of soil about nine inches high by ploughing down each side of the row, the centre of the ridge being filled with soil to enclose the bines completely. New strings are fastened from the lowered wire to the top straining wire and the bines allowed to grow freely up them. Owing to the uneven growth of the bines, it is likely that a few will not have reached a length necessary to ensure that their tips are free from the soil after layering. As such bines will die if left covered their tips should be freed from soil by pulling back their strings slightly when they will climb in the normal fashion. The process is illustrated in Fig. 2.

The technique can be adapted for different lengths of layering by an adjustment of the positions of the lower nails, the layer length being equal to the distance between them and the top nails. The bines from bedded sets can be layered by this method by planting the sets three feet apart in the rows and, using somewhat taller wirework, layering the bines for four feet.

3. Yield. Tests of the method have been made using the two Wye varieties OR55 and OJ47. The former variety yielded about nine layer cuttings per parent cutting planted (about 75 per cent. of which survived). The yield from OJ47 was only some six layer cuttings per cutting planted owing both to a reduction per plant and to the fact that only some 60 per cent. survived. A small test using Fuggle variety showed that it should at least equal the performance of OR55 and it seems likely that other commercial varieties would be similar. It is probable that these yields could be increased under favourable circumstances, particularly if attention were paid to freeing the tips of the shorter bines after layering.

In addition to the layers, each surviving cutting produced a good bedded set. The total multiplication rate should thus be about 10× per annum with suitable varieties.

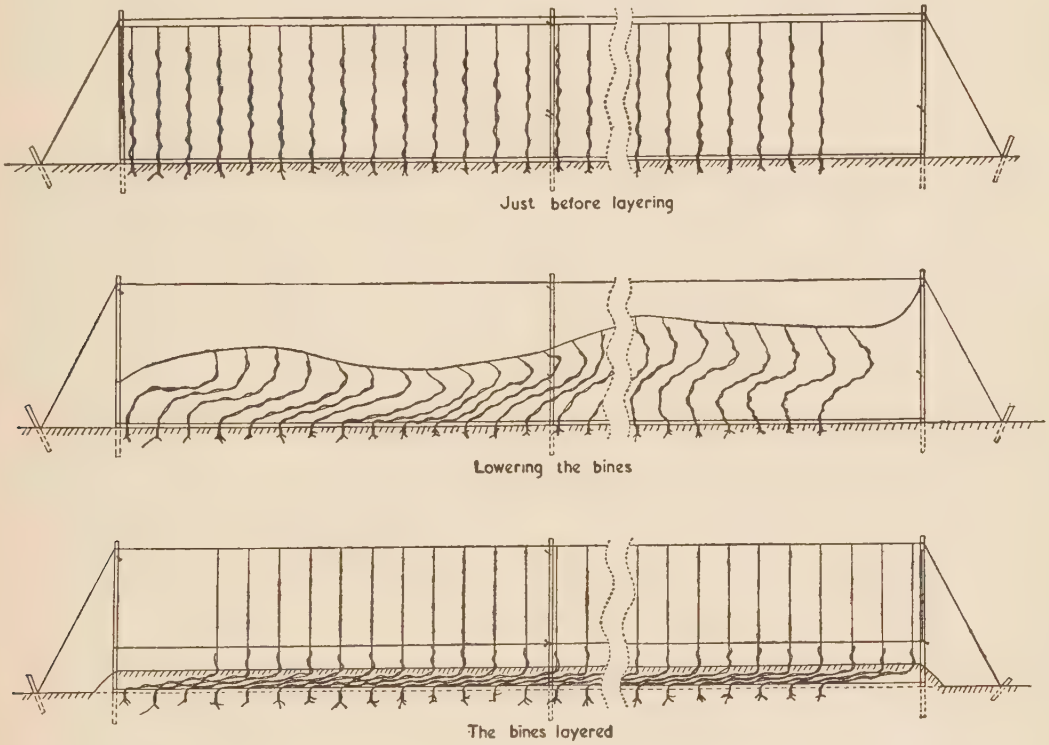

FIG. 2.

Diagram of layering method No. 3. Cuttings spaced one foot apart and layered for three feet.

Production of Bedded Sets from Layer Cuttings.

After the layers produced by any of the above methods have been lifted in the autumn they are divided into cuttings about four inches long, each containing at least one node. Near the base of the layer the nodes may be close together and thus two or more may be included in each cutting but throughout most of the layer the nodes will be more than four inches apart and a greater or lesser amount of intermediate waste material will thus be discarded. If only one node is present it should be as near the centre of the cutting as possible. Buds will be noted at each node in most cases. Any completely " blind " cuttings should be discarded.

The cuttings are grown for one year in a well-manured nursery bed in order to produce saleable bedded sets. The rows are placed three feet apart, or wider if the cultivators make this necessary, and the cuttings planted four inches apart in these rows. A narrow " grip " is made by inserting a spade all along the row some four inches deep. The cuttings are pushed into the grip with their tops just beneath the surface and the soil is then heeled against them *very firmly*.

Poles four feet high are spaced fifteen feet apart along the rows and supported by light wire or double hop string fastened to guy stumps at each end of the row. A wire or string is run along between the bases of the poles and then a continuous string laced in a V-fashion between the bottom and the top

wires, in order to provide support for the bines which grow from the cuttings. The usual sprays should be applied and cross alleys provided for convenience in spraying if the rows are long.

The " take " of the cuttings depends on many factors, e.g. weather, variety of hop and general management. Experiments by Beard* show that layer cuttings are slightly less satisfactory in this respect than " strap " cuttings but a survival of 80 per cent. may be expected under good conditions.

When the bines have died down at the end of the season, the sets are dug up and put in bundles of 25 or 50. It is often convenient to plait the dead bines to hold the sets together, then tying them round with string. Grading into two sizes is usual.

Conclusions.

It will be apparent that each method should be of value under appropriate conditions. Thus method No. 2 is likely to prove of most use in the establishment of isolated special stock nurseries although some growers may prefer method No. 1 for this purpose. Method No. 3 is attractive from several points of view as it enables a very rapid " build-up " of stock to take place and is reasonably economical in land and equipment. There is, however, the very considerable disadvantage that it is impossible to inspect the stock adequately for freedom from disease. It would thus obviously be inadvisable to continue commercial propagation year after year from young plants except under conditions where the entry of the major set-borne diseases could be ruled out entirely. It is difficult at present to decide what these conditions are as information on the means of dispersal of the diseases is small. It is suggested, therefore, that, if the method is used commercially in a special stock nursery, this should also contain a nuclear layer bed of permanent plants which, when mature, can be inspected annually for freedom from disease. The cuttings from these mature plants would then be multiplied by Method No. 3. The cuttings thus produced should not again be layered but should be grown into bedded sets for sale, further cuttings for layering being obtained annually from the permanent layer bed after this had been certified free from disease.

It must be emphasized that this suggested procedure is purely provisional and presented as a means of economic and rapid multiplication of special stock. Success does, however, depend on the absolute freedom from disease both of the parent stock and of the land in which this stock is grown, and also upon the complete isolation of the nursery which should preferably be situated away from hop growing districts. The method may be found, even then, to present too many risks to be advisable. At present, of course, the certification scheme of the Ministry of Agriculture provides for the inspection of mature parent plants only and does not apply to bedded sets grown from cuttings obtained from such plants. Only experience will show whether a service for the continuous supply of healthy bedded sets can be devised.

Summary.

A detailed account is given of three methods of hop propagation by layering, for the guidance of those who wish to raise selected stocks.

* *Rep. E Malling Res. Sta. for 1945* (1946), 104-6.

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